Volume 18 – No. 5b – 2009
REPRINT pp. 848 – 857
Original Paper

FEB A4

Fresenius
Environmental
Bulletin

EFFECTS OF LAND-USE MANAGEMENT ON SURFACE SOIL PROPERTIES, EROSION INDICES AND GREEN TEA YIELD IN HUMID BLACKSEA REGION

Turan Yüksek

PSP

Angerstr. 12
85354 Freising - Germany
Phone ++49 - (0) 8161-48420
Fax ++49 - (0) 8161-484248
Email: parlar@psp-parlar.de
www.psp-parlar.de

ISSN 1018 - 4619

EFFECTS OF LAND-USE MANAGEMENT ON SURFACE SOIL PROPERTIES, EROSION INDICES AND GREEN TEA YIELD IN HUMID BLACKSEA REGION

Turan Yüksek[1*]

[1] Faculty of Forestry, Artvin Coruh University, 08000 Artvin, Turkey.

ABSTRACT

Many basins with forest eco-systems in the north-east of Turkey have been converted to agricultural catchments, to which varying quantities and types of manure have been applied. The objectives of this study were to investigate the effects of land-use on surface soil properties in four adjacent management types: Alder coppice (control), and three types of tea cultivation management (at the first: compound fertilizer and stable manure, besides mulching; at the second, compound fertilizer and stable manure; and at the last one, only compound fertilizer) were applied to assess the impact of long-term cultivation and mulching on green tea yield.

A total of 80 soil samples (4 replications x 4 treatments x 5 soil sample points) were collected from 0-10 cm soil depth for laboratory analyses. Results according to land conversion and land-use types showed that the plant-available water (PAW), saturated hydraulic conductivity (Ksat), wet stable aggregates (WSA), soil organic matter (SOM), soil organic carbon (SOC) and green tea yield decreased significantly, while clay, permanent wilting point (PWP), bulk density (Db) and soil penetration resistance increased significantly. The highest soil degradation was determined in TC-III (only compound fertilizer). The results indicate that an accurate planning and land management model is required. This would consider the characteristics of existing land areas, help to conserve soils in tea plantations, and ensure that tea cultivation is carried out sustainably.

KEYWORDS: Land-cover change; alder coppice; tea cultivation; soil properties; green tea yield

INTRODUCTION

Land-use change is one of the most important environmental problems in the north-eastern part of Turkey, as in other parts of the world. In this region, forestry lands between 0-600 m elevation were converted to agricultural uses (particularly tea and nuts), resulting in subsequent environmental damage. The causes of land conversion are broadly categorized as related to population, personal preferences, policies and economic considerations, which result in impacts, such as environmental degradation. Much of the pressure to convert forests to agricultural uses comes from increasing population growth and demands for development.

The eastern part of Black Sea region is mountainous, with land divided into both large and small parcels. Therefore, the land which is suitable for agriculture is very limited and, within the east Black Sea region, only 2 % of the total land area is suitable for this purpose. Much of the productive lands, which are located on coastal area, have been converted to urban settlements, industry and an airport [1]. Tea is an important cash crop in the northern Black Sea region and, because of its economic value, many farmers have replaced their traditional annual as well as food crops with tea. Moreover, since 1950, many of the farmers have converted their private coppice forest to tea cultivation. While there was 2,800 ha of tea plantation in Rize in 1951, the area under tea cultivation is presently 49,968 ha, which represents 12.74 % of land area in Rize [2]. Of this, 9,255 ha of tea plantations are on land suitable for land-use classes between I-IV [3], while the other parts of the tea cultivation area (40,713 ha) are maintained on unsuitable land.

The available experience shows that human activity is the main cause of the degradation of soil, and the soil cover as a whole. Increased anthropogenic influence on soil leads, at first, to its degradation (i.e. deformation and destruction of micro-macro aggregates). By soil tillage, structural aggregates are exposed to fragmentation during rapid and fast wetting due to the impact of rain drops and the direct influence of agricultural machines [4]. Soil structure varies in time and between locations as a function of soil properties, climatic conditions and land management practices [5]. Forest vegetation generally improves the soil structure while long-term cultivation often results in structural degradation, mainly as a result of a loss of ground cover, the loss of organic inputs from forest vegetation, and due to soil disturbance from tillage [6]. It has been reported by some researchers that, as a result of the damaging of the forest vegetation and conversion to agricultural land, the texture [7] and structure, especially of topsoil, is degraded, due to the dense cultivation; while the volume weight [8-11] of the topsoil increases, pore volume (St) [10, 11], wet stable aggregate (WSA), saturated hydraulic conductivity (Ksat) and cumulative infiltration (Ic) were significantly changed [12, 13]. In addition, as a result of the conversion of forest land to agricultural uses, rain drops directly contact the soil surface and degrade the aggregate structure of the topsoil. Many researchers have reported that this increases the tendency of erosion and excessive water in the soil surface and may cause surface flow [14-17].

Tea (*Camellia sinensis* L.) is a globally important crop, and is unusual because it both requires an acid soil and also acidifies soil. Tea stands tend to be extremely heavily fertilized in order to improve yield and quality, resulting in a great potential for diffuse pollution [18]. Assessing land use-induced changes in soil systems is, therefore, essential for addressing the problem of agro-ecosystem transformation and sustainable land productivity [19]. Soil structure, organic matter content and nutrient concentrations are related to root distribution [20]. Surface application of the mulched plant material can provide protection from erosion, conserve moisture [21] and moderate soil temperature. However, little of the mulched material is initially incorporated into the soil and potential for soil compaction exists. Incorporating the mulched material by tilling the soil can enhance soil structure and loosen the soil, permitting improved air and water infiltration. However, the soil will be exposed, and oxidation of soil organic matter (SOM) will be more rapid than on sites where the mulch remains on the surface. Another consideration is that many mulched plant materials have a high C:N ratio and will tie up large amounts of nitrogen during decomposition, thus reducing nutrient availability for the new vegetation. Incorporating fertilizer application in the site preparation may provide sufficient nutrients to replace those tied up in the mulch [22]. Mulching drastically reduces the rate of evaporation. The protective effect of mulch in reducing runoff is generally related to the quantity of mulch. The infiltration rate normally increases with increasing levels of mulch applications. Lal [23] reported that mulching improves water conservation in two ways. It reduces water runoff, and decreases water loss due to evaporation from soil surface. Improvement in soil structure caused by mulching is partly due to prevention of surface crusting by checking raindrop impact, and partly due to enhancement of soil fauna activity, notably that of earthworms [24].

The aim of the present study is to determine the long-term effects of different land management strategies on a range of physical, hydrological and chemical soil properties, and the impact of mulching on topsoil properties and green tea yield. The trends in the changes observed were used to evaluate the impacts of the tea cultivation management on soil attributes, and as indicators of the sustainability of the tea cultivation management. For this purpose, a small agricultural catchment located at Pazar watershed in Rize, Turkey was chosen as study area.

MATERIALS AND METHODS

Site description and history

The study area is located in the Pazar river basin, northeastern part of Turkey (lat. 41° 08' 31"-41° 08' 31 " N and long. 40°53'49"-40°53'52" E). The area has a humid Black Sea climate: average annual precipitation is 2,019 mm, with a minimum in spring (260 mm) and maximum in autumn (758 mm), and the mean annual temperature is 14 °C (data from the Pazar Meteorological station, located 3 km distant at a similar altitude) [25]. The altitude of the study sites ranges between 70-180 m, and the mean slope of the study area is moderate (18±2 %). The soil types of the area were classified as yellow-red podsol according to the International Soil Classification System (ISCS) [26]. The rock mass is extensively volcanically disrupted, and the parent material is andesite [15]. The sand and silt content of soils varies between 40-74 % and 15-40 %, respectively. The clay content of soils varies between 8-34 %. All soil profiles in the study area had higher sand than silt and clay content. The pH values of the soils vary from 4 to 6 [16]. The organic carbon and total nitrogen values vary from 0.20 to 5.51 % and 0.04 to 0.32 %, respectively. C:N values vary between 4.4-21.8. These soils do not have any $CaCO_3$ content due to the non-calcareous parent material and high precipitation in the region [26]. The area adjacent to that of tea plantations mainly comprises stands of alder (*Alnus glutinosa* L. Gaertner subsp. *barbata)* with lesser proportions of *Rubus platyphyllos*, *Urtica* sp., *Frangula alnus* Miller., and annual forage plants [15, 16]. Between 1950-1980, 4-5 ha of alder coppice forest was clear-cut annually and, in total, 120-150 ha of forestland has been converted to tea plantation in Pazar river basin. The terraces on which the tea is cultivated range between 40-60 m in length and 0.4-0.6 m width, and the soils of the terraces were tilled to a depth of 0.6 m.

Experimental design and soil sampling

A preliminary study was carried out in May 2006 with the purpose of determining the tea plantations in which various procedures (mulching, organic or artificial manure, trimming) are applied. For this purpose, a public survey and visual observation was carried out in 2006. In the present study, research sites were categorized according to these visual observation and public survey. Four management types were identified (Table 1).

Four sample plots (20 m x 30 m) were established per management area for the purpose of data collection. Soil

TABLE 1 - The application on tea plantations (mulching, organic or artificial manure).

Experimental sites	Tea Plantation Date	Mulching	Mulching + organic manure	Artificial manure
TC-I (Site-I) (Tea cultivation)	1974	Between 1974-1980, mulch was applied in tea terraces using the leaves collected from beneath alders. With this method, approximately 200 kg leaves were spread over 0.1 hectares of tea terrace.	Between 1980-1990, low quantities of mulch and organic animal manure were used. Approx. 50 kg mulching and 250 kg animal manure, kept for 1 year, were applied to 0.1 hectares of land.	Until the years 1990-2000, 50 kg ammonium sulfate manure was used in 0.1 hectares. Between the years 2000-2008, an average of 50 kg N-P-K (2:1:1) manure mixturess were used in 0.1 hectares. Manure application was made in March each year.
TC-II (Site-II) (Tea cultivation)	1978	Using the leaves collected under alders between 1978-1980 mulching was applied in tea terraces. With this method, approximately 200 kg leaves were spread over 0.1 hectares of tea terrace.	Between 1980-1985 approximately 250 kg animal manure which was kept for one year was spread over 0.1 hectares of land.	Until the years 1990-2000, 50 kg ammonium sulfate manure was used in 0.1 hectares. Between the years 2000-2008, an average of 50 kg N-P-K (2:1:1) manure mixtures were used in 0.1 hectares. Manure application was made in March each year.
TC-III (Site-III) (Tea cultivation)	1979	Mulching is not applied	Mulching or organic manure is not applied	Until the years 1980-2000, 50 kg ammonium sulfate manure was used in 0.1 hectares. Between the years 2000-2008, an average of 50 kg N-P-K (2:1:1) manure mixtures were used in 0.1 hectares. Manure application was made in March each year.

samples were collected during spring from the experimental sites having the same physiographic unit, soil conditions and slope aspects. Soil samples were taken randomly at a soil depth of 0–10 cm in each plot of the study area, comprising five samples where the soil had been disturbed, and five undisturbed samples. The undisturbed soil samples were obtained using a steel core sampler of a 98.16 cm^3 volume (5 cm in diameter and 5 cm in height). Prior to analysis of physical and chemical soil characteristics, all samples were air-dried at room temperature and passed through a 2 mm soil sieve.

Laboratory analysis

The particle size distribution was determined by the Bouyoucos hydrometer method using disturbed soil samples sieved through a 2-mm mesh-sized sieve [27]. Dispersion ratio (DR) was determined according to the methods described by Middleton [28]. The clay and silt fractions obtained by chemical dispersion were taken as Tc and Ts, while water-dispersible clay and silt (WDCS) was obtained as described above, except that no chemical dispersant was used. Colloid moisture equivalent ratio (C-MER) and erosion ratio (ER) were determined according to the methods described by Balcı [29]. The field capacity (FC) was measured by subjecting saturated soil samples <2 mm to tensions of 1/3 bars. The permanent wilting point (PWP) was measured at 15 bar until equilibrated in pressure membrane and pressure plate extractors. The plant-available water (PAW) content was calculated from the difference between the field capacity and the permanent wilting point [30]. The bulk density, total porosity, and saturated hydraulic conductivity were determined with the undisturbed soil samples. The dry bulk density (Db) was determined by the core method [31]. Particle density (Dp) was determined by the pycnometer method. Total porosity (St) was calculated from the following equation: $[St\ (\%) = (1-D_b/D_p) \times 100]$, where St is total pore space, D_b is bulk density and D_p is soil particle density [32]. A wet sieving method was used to determine the water stable aggregates (WSA) [33]. The saturated hydraulic conductivity (Ksat) was measured by the falling-head method according to Klute and Dirksen [34]. The samples were used for saturation and consecutively oven-dried at 105± 2 °C to determine bulk density. The soil penetration resistance (SPR) [35] was measured as 0-40 cm depth. 20 measurements were recorded for each plot, at depth intervals of 5 cm, using a manual (hand-pushed) 13-mm diameter cone (30°) penetrometer. Cumulative infiltration (Ic) in the field was determined using a single ring infiltrometer [36] having a cylinder of 20 cm diameter and height, and 4 measurements were done on a leveled surface at each plot. The site was prepared by removing all residues and any large clods (in tilled soils) that would interfere with achieving a levelled surface. The cylinder was inserted into the surface to a depth of approximately 5 cm. The change in water depth of the cylinder was measured at time intervals of 5, 10, 15, 20, 30, 40, 60, 75, 90, 105 and 120 min. Soil pH was determined in a 1:2.5 soil/water mixture [37]. Electrical conductivity (EC) (of the saturation) was determined according to the method described by Rhoades [38]. Lime ($CaCO_3$) was determined according to the method described by Richard and Donald [39]. The concentrations of soil organic matter (SOM) and soil organic carbon (SOC) were determined using the Walkley-Black method [40]. Total Nitrogen (TN) was determined using the Kjeldahl method [41]. The C:N ratio was calculated from the following equation:

$$[C:N = (SOC/\ Total\ N)] \quad (1)$$

Where C is carbon, N is total nitrogen, SOC is soil organic carbon, and Total N is total nitrogen.

Estimation of green tea yield

Green tea yield in the tea plantations, between the years 1975-2005, was calculated based on the sales of the producers from the tea gardens in which related test sites were created and the values which were registered to the tea account book. By adding the value of all green tea sold from the related test sites, the total annual green tea yield was calculated.

Statistical analysis

Statistical analysis was performed using of variance (ANOVA), and the means were subjected to Duncan test (P <0.05) to identify the main differences between the treatments (sites). The data were also examined for correlation using SPSS software package. Mean values found for all properties are shown in relevant tables.

RESULTS AND DISCUSSION

Soil texture and water characteristics

The soil types of the study area were sandy loam (in control site), sandy clay loam (in TC-I and TC-II sites), and light clay (in TC-III site) (Table 2).

The mean value for sand content was the highest in control site, followed by the TC-I, TC-II and the TC-III sites. Compared to control site, sand ratio was significantly lower ($p<0.012$), while the clay ratio was significantly higher ($p<0.008$) in TC-I, TC-II and TC-III sites (Table 2). The FC decreased from control site to TC-I, TC-II, and then TC-III site. The PAW was significantly lower ($p<0.021$), while PWP was significantly higher ($p<0.038$) in the TC-I, TC-II and the TC-III than in control site. Under normal conditions, a change of land usage would not be expected to cause a large change in the sand and clay ratios. However, with field transformation in the research area, terraces at an approximate width of 60-90 cm were formed, stones in the terraces larger than 10 cm were removed and tea seedlings were set after discombobulating the soil. Also, beans and other crops were seeded in the newly set tea terraces and the soil was hoed. It can be said that these operations caused displacement of the existing topsoil and, as a result of this, the texture and the structure of the soil changed. Numerous previous studies have reported that discombobulating changes the soil's structure, especially in the upper part of the soil profile [7]. Brye *et al.* [42] reported that land leveling significantly altered soil particle-size fractions, although the soil textural class remained a silt loam. In the forest areas transformed to tea cultivation, there is less protection of the soil and, as a result of this, in terraces were tea cultivations are present, some of the topsoil had been removed by surface flow. This can be shown as another effect causing the soil's texture to change.

In the tea cultivation sites, due to heavy field traffic and hoeing, the volume weights and penetration values of

TABLE 2 - Investigated soil properties in 0–10 cm soil depth (mean± Std Dev).

Soil Characteristics	Land-use type				F ratio	P
	Control Site	Tea cultivation (TC)				
	(Alder coppice)	TC- I	TC- II	TC- III		
Sand (%)	70.70±(6.75)^{a}	61.50±(5.88)^{b}	58.90±(5.61)^{b}	54.10±(5.13)^{c}	4.35	0.012
Clay (%)	12.25±(1.30)^{c}	20.55±(2.60)^{b}	21.88±(2.80)^{b}	25.67±(3.12)^{a}	8.24	0.008
Silt (%)	17.05±(2.21)^{a}	17.95±(2.23)^{a}	19.22±(2.54)^{a}	20.23±(2.88)^{a}	0.56	0.755
FC (% vol.)	33.16±(3.11)^{a}	32.54±(3.38)^{a}	31.78±(3.51)^{a}	30.34±(3.77)^{a}	0.44	0.815
PWP (% vol.)	14.18±(1.52)^{d}	16.34±(2.11)^{c}	17.90±(2.29)^{b}	20.40±(2.58)^{a}	3.77	0.038
PAW (% vol.)	18.98±(1.22)^{a}	16.20±(2.06)^{b}	13.88±(1.33)^{c}	9.94±(1.04)^{d}	4.15	0.021
Dp(gcm^{-3})	2.32±(0.25)^{a}	2.29±(0.33)^{a}	2.30±(0.34)^{a}	2.14±(0.25)^{b}	2.79	0.042
Db (gcm^{-3})	0.98±(0.12)^{c}	1.09±(0.17)^{b}	1.11±(0.17)^{b}	1.18±(0.22)^{a}	4.67	0.004
St (%)	57.75±(5.88)^{a}	52.40±(4.45)^{b}	51.74±(4.40)^{b}	44.86±(4.12)^{c}	10.92	0.001
WSA (%)	72.50±(6.22)^{a}	66.50±(5.77)^{b}	64.80±(5.71)^{b}	59.20±(5.24)^{c}	3.88	0.023
Ksat (mmh^{-1})	44.56±(4.88)^{a}	28.55±(2.50)^{b}	21.70±(1.98)^{c}	12.87±(1.12)^{d}	10.65	0.002
Ic ($mm\ h^{-1}$)	452±(12.98)^{a}	320±(12.10)^{b}	283±(11.57)^{c}	118±(10.79)^{d}	14.99	0.000
SPR (MPa)	0.315±(0.11)^{c}	0.361±(0.13)^{b}	0.374±(0.13)^{b}	0.576±(0.17)^{a}	5.12	0.008
DR (%)	10.46± (1.09)^{d}	18.77± (1.55)^{c}	28.25± (3.75)^{b}	55.79± (5.75)^{a}	10.96	0.001
C/MER	0.37±(0.10)^{a}	0.656±(0.14)^{b}	0.688±(0.19)^{c}	0.789±(0.24)^{d}	7.92	0.003
ER (%)	28.27±(2.16)^{c}	28.63±(2.80)^{c}	41.06±(4.15)^{b}	70.71±(8.89)^{a}	16.78	0.000
pH (1/2.5 H_2O)	4.55±(0.45)^{a}	4.13±(0.20)^{b}	3.99±(0.19)^{b}	3.53±(0.17)^{c}	2.92	0.039
E.C ($dS.m^{-1}$)	0.27±(0.06)^{c}	0.31±(0.06)^{b}	0.33±(0.06)^{b}	0.41±(0.09)^{a}	3.52	0.034
$CaCO_3$ (%)	0.43±(0.11)^{b}	0.54±(0.12)^{a}	0.55±(0.12)^{a}	0.57±(0.15)^{a}	4.56	0.025
SOM (%)	5.88±(0.96)^{a}	4.50±(0.89)^{b}	4.01±(0.89)^{c}	2.65±(0.71)^{d}	4.90	0.019
SOC (%)	3.57±(0.65)^{a}	2.54±(0.45)^{b}	2.41±(0.40)^{c}	2.05±(0.35)^{d}	7.35	0.007
Total N (%)	0.25±(0.05)^{a}	0.22±(0.03)^{b}	0.21±(0.03)^{b}	0.16±(0.03)^{c}	2.91	0.040
C: N Ratio (%)	14.28±(1.95)^{a}	11.54±(1.86)^{c}	11.48±(1.86)^{c}	12.81±(1.98)^{b}	2.88	0.041
STC^{x}	SL	SCL	SCL	LC	--	--

FC: Field Capacity, PWP: Permanent wilting point, PAW: Plant-available water, Dp: Particle density, Db: Bulk density, St: Total porosity, WSA: Water-stable aggregate, Ksat: Saturated hydraulic conductivity, Ic: Cumulative infiltration ($mm\ h^{-1}$), E.C: Electrical conductivity, SOM: Soil organic matter, SOC: Soil organic carbon, STC: Soil texture class, DR: Dispersion ratio, ER: Erosion ratio,: Colloid-moisture equivalent ratio, P: Significance Level. Values are means, and Significance levels are: NS represents non-significant, * 0.05–0.01, ** 0.01–0.001 and *** 0.001; values within columns followed by the same letter are not statistically different at 0.05 significance level.. ^{X}: According to international soil texture class, SCL: Sandy Clay Loam; SL: Sandy Loam; LC: Light clay. SPR: Soil penetration resistance.

the soil increased (TC-III> TC-II> TC-I) by a significant amount, and the total pore volume and the net structure of the pores were destroyed. Resulting from this, the penetration of water into the soil was slower and the FC and PAW values of the soil decreased. The decrease in the amount of organic matter can be seen as one reason for the decrease of the field capacity and plant-available water content in the tea and forest soils, with increasing depth. As the amount of organic matter decreases, the water holding and available water capacities of the soil decrease [7, 43]. Terracing with human power and, applying high levels of organic fertilizers (in the first six years) and mulching (in the first 10 years) following the tea setting help to increase the plant-available water capacity of the soil in the TC-I area. The use of organic inputs in the terraces formed by human power increases the water-resistant aggregate stability of the soil. In these terraces, the volume weight of the soil decreases when compared to terraces in which no organic input is used, whereas the water holding capacity, plant-available water and hydraulic conductivity increase [7]. Under normal conditions, the water holding capacity and PAW content in the forest soils can be expected to be higher than the cultivated tea soils. However, in the research region, the dry leaves of the alders are collected and used in the tea terraces for compost or other purposes (such as animal bedding in stables). Also, the herbaceous plants growing under the alders are being harvested and used as animal food or animal bedding in stables. These operations cause a loss of minerals in the forest ecosystem and have negative effects on the soil properties. Le Bissonnais [44] mentioned that the aggregate stability of the soil increases with the increase of organic materials in the soil. Yüksek [15] found that the water holding capacity of the soils decreases, and the surface run-off increases in heavy rain conditions, as a result of using the organic wastes that are presently collected from the forest for different purposes.

Bulk density (Db), total porosity (St), water-stable aggregates (WSA), and soil penetration resistance (SPR)

The highest Db (1.18 $g.cm^{-3}$) and the lowest St (44.86%) were determined in TC-III, while the lowest Db (0.98 $g.cm^{-3}$) and highest St (57.75%) were determined for the control site (Table 2). According to mean values, Db content followed the sequence TC-III>TC-II>TC-I> Control; and mean St followed the sequence Control>TC-I> TC-II>TC-III. The mean WSA content was determined to be 59.20-66.50 %. The highest WSA (72.50%) was found in the control site, while the lowest WSA (59.20%) was determined in the TC-III (Table 2).

It can be stated that the dense cultivation and trampling of soil in the tea plantations decreased the pore volume, especially in the topsoil, and caused bulk weight increase. Under normal conditions, as a result of the dense plantation traffic and cultivation, total porosity can be expected to be lower and bulk weight is expected to be higher. Organic wastes applied to the tea terraces improve the structure of the topsoil to a certain degree. This prevents the further decrease of pore volume and a further increase in bulk weight. Many researchers have reported that compost and animal manure applied to the topsoil decreased bulk weight [10, 45, 46], but increased WSA and total porosity value [5, 47-49].

The effect of soil moisture content is quite important in the increase of soil penetration resistance. However, the humidity levels held at critical tensions at the tea and forest soils are close to each other. Statistically, the penetration values in both of the land-use types are significantly different. It can be said that this is due to the field traffic present in the tea soils. Many researchers reported that the SPR increases as a result of the increase in the topsoil traffic density [43].

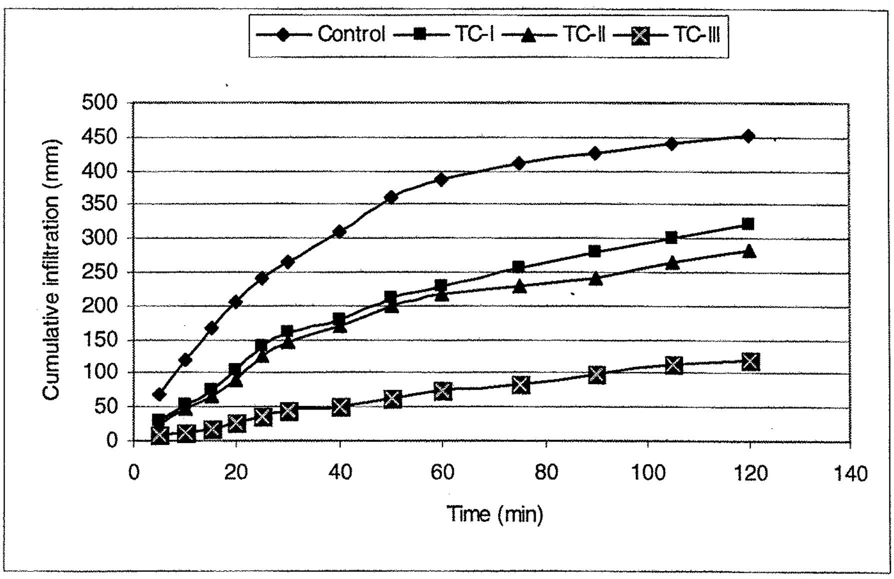

FIGURE 1 - Cumulative infiltration on control, TC-I, TC-II and TC-III sites.

Saturated hydraulic conductivity (Ksat) and cumulative infiltration (Ic)

The highest Ksat and Ic values were determined in control sites, and the lowest Ksat and Ic were determined in TC-III (Table 2, Fig. 1). Average permeability values were 44.56 mmh^{-1} in control site and 12.87-28.55 mmh^{-1} in tea plantations.

As seen in Fig. 1, the mean Ic contents in TC-I and TC-II were lower than the control site but was higher than that of TC-III.

Soil hydraulic properties, including soil hydraulic conductivity function and water retention characteristics, are affected by soil texture, bulk density, soil structure, and organic carbon content, many of which are strongly influenced by land-use and management, even though the soil classification may be the same. Due to the procedures applied to soils in tea plantations, with the degradation of texture and soil structure, the macro-pores and pore structure of the soil were damaged. Surface pressure from trampling and the increase in soil bulk weight caused Ksat and Ic values to decrease. The fact that root structure and the total root density were lower when compared to the forest soils had an effect on the low Ksat and Ic values. The temporal change of land-use and management, or natural disturbances and cycles, such as diurnal and seasonal changes, can affect soil hydraulic properties. Soil compaction, caused by human trampling, wheeled traffic or animal grazing, can immensely destroy the large-pore structure and, therefore, reduce saturated or near-saturated hydraulic conductivity [50]. Tilling can create more large pores for surface soil but may also disrupt pore network connectivity, especially for subsurface flow [51]. Other factors, such as soil organism activity, root dynamics, and formation of cracks at the surface during dry periods, all contribute to the dynamic nature of soil hydraulic properties in different soils [8].

Dispersion ratio (DR), Colloid/Moisture equivalent ratio (C-MER), and Erosion ratio (ER)

The highest DR, C-MER and ER values were determined in TC-III, while the lowest ones were found in the control site. According to mean values, DR and C-MER were significantly higher in tea cultivation sites, with regard to control site, while mean ER was significantly higher in TC-II and TC-III compared to control and TC-I (see Table 2). The vegetation in the control site enriched the soil in terms of organic matter, and prevented rainfall from impacting the soil surface and eroding the soil by dislodging soil particles. In addition, mulching and the application of organic manure to the soil similarly improved soil properties and protected the soil against the direct effect of rain drops. For this reason, DR, C-MER and ER values of the soils in control sites and long-term mulching/organic manure sites were found to be significantly lower than those of the other sites (TC-II and TC-III). Many researchers reported that mulching protects the topsoil from the direct effect of rain drops and improves soil properties [21, 23, 24]. Another reason for higher DR, C-MER and ER contents in tea plantations is probably that the aggregate structure of topsoil in these sites is degraded due to the cultivation of these soils along the terrace in certain intervals. Many previous studies based in different regions [14, 16, 17] have reported the DR, C-MER and ER contents in cultivated soils to be higher than those in forest soils.

Values of pH and EC

The highest pH and the lowest EC values were determined in control site, while lowest pH and highest EC were determined in TC-III (Table 2). Different types of mulching and manure use were applied in tea plantations. With the mulching applied in the earlier period, the acidification of tea soils was prevented to some degree. However, as result of excessive use of chemical fertilizers and washing out, the acidity values of tea soils have been increased. It was reported that generally there is a strong positive relationship between the clay content in the soils and EC [52]. In addition, it was reported that the application of mulch on the soil surface has an effect on the increase in EC values [46]. In the present study, clay content and EC values in test sites followed the sequence: TC-III> TC-II>TC-I>Control. In other words, there is a positive correlation between clay content and EC value.

The movement of electrons through bulk soil is complex. Electrons may travel through soil water in macropores, along the surfaces of soil minerals (i.e. exchangeable ions), and through alternating layers of particles and solutions [52]. Therefore, multiple factors contribute to the variability of soil EC, including factors that affect the amount and connectivity of soil water (e.g. bulk density, structure, water potential, precipitation, timing of measurement), soil aggregation (e.g. cementing agents, such as clay and organic matter, soil structure), electrolytes in soil water (e.g. salinity, exchangeable ions, soil water content, soil temperature), and the conductivity of the mineral phase (e.g. types and quantity of minerals, degree of isomorphic substitution, exchangeable ions) [53].

Soil organic matter (SOM) and soil organic carbon (SOC), Total N, C:N ratio and lime

While the average value for organic matter content varied between 2.65-4.50% in tea soils, this value reached 5.88% in the control site. The highest SOM, SOC, total N and C:N contents were determined in the control site, while the lowest SOM, SOC and total N were found in TC-III. According to the test sites, the change in SOM and SOC values are statistically significant (Table 2).

It can be stated that the land-use change and the cultivation in tea terraces caused a decrease in the organic matter content of the soils. However, it can also be stated that the organic matter contents in tea topsoils are not particularly low. Mulching and organic manure were applied to tea topsoil during a certain period of time, preventing a decrease of organic matter in tea topsoil. Land-use change and long-term cultivation may lead to changes in SOM quantity and quality [54]. Soil carbon loss first occurs pre-

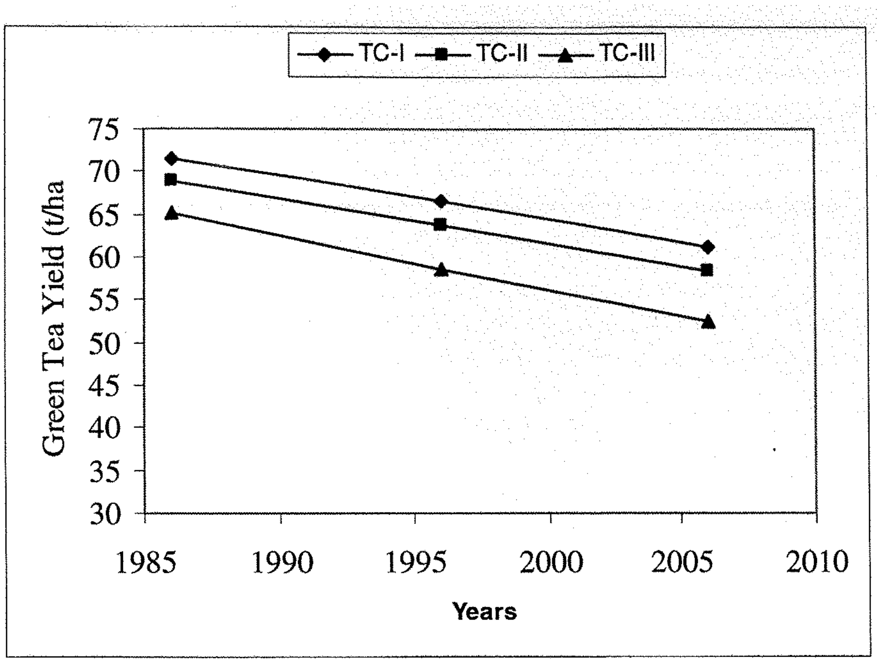

FIGURE 2 - Green tea yield in experimental sites (TC-I, TC-II, and TC-III).

dominately by mineralization after conversion of virgin land into cultivated land, followed by soil erosion as the dominating process of soil carbon loss in later years [55]. It can be suggested that the application of organic wastes, collected from the forest and stable manure to tea terraces, caused the total nitrogen amount in the tea topsoil to be higher than tea soils that did not have organic inputs. In addition, thanks to the organic wastes and the spread dry tea leaves, the carriage of N and P by surface flow was prevented to some extent. This may have caused the relatively high N value. However, due to the fact that the study area is located in a humid region (annual average precipitation approximately 2,000 mm) and, in addition, due to the topsoil cultivation in the terraces, a certain amount of N may have been leached from the soil. Leaching losses are influenced by soil texture, N management, and irrigation practices [56].

Green tea yield (Kg/ha)

Total annual yield (1976-2006) of tea plantation in hectares is shown in Fig. 2. Generally, tea yield decreased in TC-I (7.14-14.42%), TC-II (7.31-15.32%) and TC-III (10.28-19.49%) in given ratios. The values indicate that the greatest decrease in tea yield occurred at TC-III site, in which mulching + organic manure was not applied (Fig. 2).

As Fig. 2 shows, although mulching and organic manure was applied for a certain period, tea yield still decreased. However, this decrease was lower than the one observed in the test site in which only chemical fertilizer was applied. The application of mulch + organic manure in tea terraces increases the crop yield when compared with the test site, in which only chemical fertilizer was applied. Forest soils, in general, have higher organic matter content than agricultural soils. This probably has an effect on the relatively high yield in the new tea plantations. Degradation of soil properties in the following years (for example, decrease in organic matter, pressure, decrease in permeability etc) has probably caused loss of yield in tea plantations [9]. The aging of tea cuttings causes tea yield to decrease. In addition, while, in the first years after establishing the plantation, tea cuttings were young having a positive effect on the yield; aging may have a negative effect on the yield of the tea cuttings. In addition, the change in climate (10% increase in total precipitation amount, especially in the last 10 years) may have caused more plant nutrients to be leached with surface flow or the displacement of the topsoil with erosion, which may have contributed to the reduced yield of the soils in which tea plantations were established.

CONCLUSIONS

As a result of the degradation of alder coppice and their conversion to tea plantations, their 10 physical (sand, clay, PWP, D_b, Dp, St, WSA, DR, C-MER, and ER), 2 hydro-physical (Ksat and Ic) and 6 chemical (pH, EC, $CaCO_3$, SOM, SOC, and total N) properties changed significantly. As a result of forest degradation, the erodibility values of the soils increased and green tea yields decreased. With the mulching application, soil properties were protected to some extent, and further reduction of yield was prevented. There is insufficient availability of land in the Pazar area that is suitable for agriculture. For this reason, the introduction of agriculture on ill-suited land involves a high level of risk of declining crop yields and environmental damage. For the protection of soils in these areas and to enable more sustainable forms of agriculture, an accurate planning and land management model should be prepared by considering the properties of the existing soils. In tea plantations, in order to protect soils and increase yields, mulching applications should continue, and the effects of mulching applications on soil protection and tea yield should be investigated. This strategy can help land managers to utilize the soils more effectively and productively.

REFERENCES

[1] Yüksek, T., Kalay, H.Z. and Yüksek, F. (2004). Land use problems in Pazar creek watershed. Journal of Science Institute of Süleyman Demirel University 8-3, 121-127.

[2] Anonymous (2006). The past and present day of tea, http://www.biriz.biz/cay/turkcay.htm#icf (accessed 16 January 2006), [in Turkish].

[3] Anonymous, (1993). Available land properties of city of Rize. Publications of General Offices of Village's Foundation, City Report no: 53, Ankara, Turkey, [in Turkish].

[4] Gajic, B., Dugalic, G., and Djurovic, N. (2006). Comparison of soil organic matter content, aggregate composition and water stability of gleyic fluvisol from adjacent forest and cultivated areas. Agronomy Research 4 (2), 499-508.

[5] Angers, D.A. and Chenu, C. (1998). Dynamics of soil aggregation and C sequestration. In: Soil processes and the carbon cycle. Lal, R., J.M. Kimble, R.A. Follett, and B.A. Stewart eds. CRC Press, Boca Raton, FL. Chapter 14, pp.199-206.

[6] Karunatilake, U. and Van Es, H.M. (2002). Temporal and spatial changes in soil structure from tillage and rainfall after alfalfa-corn conversion in a clay loam soil. Soil and Tillage Research 67,135-146.

[7] Querejeta, J.I., Rolda´n, A., Albaladejo, J. and Castillo, V. (2000). Soil physical properties and moisture content affected by site preparation in the afforestation of a semiarid rangeland. Soil Science Society of America Journal, 64,2087–2096.

[8] Guérif, J., Richard, G., Dürr, C., Machet, J.M., Recous, S. And Roger-Estrade, J.(2001). A review of tillage effects on crop residue management, seedbed conditions, and seedling stablishment. Soil Till. Res. 61, 13–32.

[9] Dang, V.M., Anderson, D.W., and Farrell, R.E. (2002). Indicators for assessing soil quality after long-term tea cultivation in Northern Mountainous Vietnam. 17 th WCSS, 14-21 August, 2002, Thailand, Symposium no:32, Paper no:1010, pp:1010-1 and 1010-10.

[10] Celik, I. (2005). Land-use effects on organic matter and physical properties of soil in a southern Mediterranean highland of Turkey. Soil & Tillage Research 83, 270–277.

[11] Cotler, H. and Ortega-Larrocea, M.P. (2006). Effects of land use on soil erosion in a tropical dry forest ecosystem, Chamela watershed, Mexico. Catena 65, 107 – 117.

[12] Gutierrez, J., Sosebee, R.E. and Spaeth, K.E. (1995). Spatial variation of runoff and erosion under grass and shrub cover on a semiarid rangeland. In: Ward, T.J. (Editor), Watershed Management-Planning for the 21st Century. American Society of Civil Engineers, San Antonio, TX, pp. 11 – 20.

[13] Zimmermann, B., Elsenbeer, H., De Moraes, J. M.b. (2006). The influence of land-use changes on soil hydraulic properties: Implications for runoff generation. Forest Ecology and Management 222, 29–38.

[14] Karagül, R. (1999). Investigations on soil erodibility and some properties of soils under different land use types in Sogutludere Creek Watershed near Trabzon. Turkish J. Agric. For. 23, 53-68 (in Turkish).

[15] Yüksek, T. (2001). Investigations on soil erodibility and some properties of the soils under different land use types in Pazar creek watershed, near Rize-Turkey (Ph.D Thesis). Karadeniz Technical University, Science Institute, 204 pages, Trabzon (in Turkish).

[16] Yüksek, T., Kalay, H.Z., and Yüksek, F. (2004). Comparison of some soil properties between maize cultivation areas and adjacent alder *[(Alnus glutinosa (l.) Gaertner* subsp. *barbata* (C.A.Meyer) yalt)] Stands in Kesikköprü Village, Pazar in Turkey, International Soil Congress on Natural Resource Management For Sustainable Development, June 7-10, , C1, P. 1-8, Erzurum-Turkey.

[17] Yilmaz, M, Usta, A., Altun, L., and Tilki, F. (2007). Effects of land-use regime on soil erodibility indices and soil properties in Ünye, Turkey. Fresenius Environmental Bulletin. 16-No.12b, 1636-1642.

[18] Han, W., Kemmitt, S.J. and Brookes, P.C. (2007). Soil microbial biomass and activity in Chinese tea gardens of varying stand age and productivity. Soil Biology and Biochemistry 39 (7), 1468-1478.

[19] Tchienkoua, M., and. Zech, W. (2004). Organic carbon and plant nutrient dynamics under three land uses in the highlands of West Cameroon. Agriculture, Ecosystems & Environment 104 (3), 673-679

[20] Burke, I.C., Reiners, W.A., Sturges, D.L. and Matson, P.A. (1987). Herbicide treatment effects on properties of mountain big sagebrush soils after fourteen years. Soil Science Society of America Journal 51, 1337– 1343.

[21] Iles J.K. and Dosmann, M.S. (1999). Effect of organic and mineral mulches on soil properties and growth of fairview flame red maple trees. Journal of Arboriculture 25(3), 163-167.

[22] Sanchez, P.A. and Jama, B.A. (2002). Soil fertility replenishment takes off in East and Southern Africa. In: Vanlauwe, B., Diels, J., Sanginga, N. and Merckx, R. (Editors). *Integrated* Plant Nutrient Management in Sub-Saharan Africa. Wallingford: CAB International. pp. 23-46.

[23] Lal, R. (1976). Soil Erosion on Alfisols in Western Nigeria, V. The changes in physical properties and the response of crops. Geoderma 16, 419–431.

[24] Lal, R., Vleeschauwer, D.D., and Nganje, R.M. (1980). Changes in properties of newly cleared tropical Alfisol as affected by muclhing. Soil Science Society America Journal 44, 827-833.

[25] Anonymous, (2008). Some climatic data of Rize city in the year between 1970- 2007, Turkish State Meteorological Service, Ankara, [in Turkish].

[26] Aydınalp, C. and Fitz Patrick E.A. (2004). Classification of great soil groups in the east Black sea basin according to international soil classification systems. Journal of Central European Agriculture. 5(2), 119-126.

[27] Bouyoucos, G. (1962). Hidrometer method improved for making particle size analysis of soils. Agronomy Journal 54, 464-465.

[28] Middleton, H.E. (1930). Properties of soils which influence soil erosion. USDA Technical Bulletin no:178.

[29] Balcı, A.H. (1996). Soil conservation. İstanbul University, Faculty of Forestry, publication no:439, İstanbul, Turkey (in Turkish).

[30] Klute, A. (1986).Water retention: Laboratory methods. In: Klute, A. (Eds.) Methods of soil analysis, Part I, physical and mineralogical methods, second edition, SSSA, Inc, Madison, WI, 635-662.

[31] Grossman, R.B. and Reinsch, T.G. (2002). The solid phase, bulk density and linear extensibility: Laboratory methods. In: Dick, W.A. (Eds) Methods of soil analysis, part 4- physical methods, SSA Book Series: 5, SSSA, Inc, Madison, WI, pp.201-228.

[32] Flint, A. and Flint, L.E. (2002). Particle density, laboratory methods. In: Dick, W.A. (Eds) methods of soil analysis, part 4- physical methods, SSA Book Series: 5, SSSA, Inc, Madison, WI, pp.229-240.

[33] Kemper, W.D., and Rosenau, R.C. (1984). Soil cohesion as affected by time and water content. Soil Sci. Soc. Am. J. 48, 1001-1006.

[34] Klute, A. and Dirksen, C. (1986). Hydraulic conductivity and diffusivity: laboratory methods. In: Klute, A. (Ed.) methods of soil analysis: part 1. physical and mineralogical methods. Agronomy Monograph. American Society of Agronomy, Madison, WI, pp. 687– 734.

[35] Bradford, J.M. (1986). Penetrability, methods of how farmers assess soil health and quality, Journal of Soil Water Consoil Analysis 50, 229-236.

[36] Bouwer, H. (1986). Intake rate, cylinder infiltrometer. In: Klute, A. (Eds.) methods of soil analysis. Part I, Agronomy no: 9, SSSA, Inc, Madison, WI, pp.825-844.

[37] Karaoz, O. (1989). Analyze methods of some chemical soil properties (pH, Carbonates, Salinity, Organic Matter, Total Nitrogen, Available Phosphorus), review of the Faculty of Forestry, University of İstanbul 39 (B3), 64-82, [in Turkish].

[38] Rhoades, J. D. (1996). Salinity: Electrical conductivity and total dissolved solids. In: Sparks, D.L. (Ed.). Methods of Soil Analysis, Part 3—Chemical Methods. Soil Science Society of America, Madison, WI, pp. 417-435.

[39] Richard. H.L and Donald. L.S. (1996). Methods of Soil Analysis. Part 3. Chemical Methods. Soil Science of America and American Society of Argonomy. SSSA Book Series no.5. Madison, W.I, P.437.

[40] Nelson, D.W. and Sommers L.E. (1996). Total carbon, organic carbon, and organic matter. In A.L. Page et al., (Editors), Methods of Soil Analysis, Part 2, 2nd ed., Agronomy. 9: Am. Soc. of Agron., Inc. Madison, WI, pp. 961-1010.

[41] Bremmer, J.M. (1965). Total nitrogen. In: Black, C.A., Evans, D.D., White, J.L., Ensminger, L.E. and Clark, P.E. (Eds). Methods of soil analysis. Part 2: Chemical and microbiological properties, Amer. Soc. Agron. Inc., Madison, Wisconsin, pp. 1149-1178.

[42] Brye, K.R., Slaton, N.A. and Richard, N. J. (2006). Soil physical and biological properties as affected by land leveling in a clayey aquert. Soil Sci. Soc. Am. J. 70, 631–642.

[43] Brady, N.C. and Weil, R.R. (1999). The nature and properties of soils. Prentice Hall Publishing, New Jersey.

[44] Le Bissonnais, Y. (1996). Aggregate stability and measurement of soil crustability and erodibility: I. Theory and methodology. European Journal of Soil Science 47, 425–437.

[45] Aggelides, S.M. and Londra, P.A. (2000). Effects of compost produced from town wastes and sewage sludge on the physical properties of a loamy and clay soil. Bioresources Technology 71, 253–259.

[46] Johnson, G.A., Davis, J.G., Qian, Y.L. and Doesken, K.C. (2006). Topdressing turf with composted manure improves soil quality and protects water quality. Soil Science Society of America Journal 70, 2114-2121.

[47] Tisdall, J.M. and Oades, J.M. (1982). Organic matter and water-stable aggregates in soils. Journal of Soil Science 33,141–163.

[48] Chenu, C., Le Bissonnais, Y. and Arrouays, D. (2000). Organic matter influence on clay wettability and soil aggregate stability. Soil Science Society of America Journal 64, 1479–1486.

[49] Garnier, P., Ezine, N., De Gryze, S. and Richard, G. (2004). Hydraulic properties of soil–straw mixtures. Vadose Zone Journal 3, 714-721.

[50] Drewry, J.J. and Paton, R.J. (2005). Soil physical quality under cattle grazing of a winter-fed brassica crop. Australian Journal of Soil Research 43(4), 525-531.

[51] Bouma, J. (1991). Influence of soil macroporosity on environmental quality. Advanced Agronomy 46,1-37.

[52] Rhoades, J. D., Manteghi, N. A., Shouse, P. J. and Alves, W.J. (1989). Estimating soil salinity from saturated soil-paste electrical conductivity. Soil Science Society of America Journal 53, 428-433.

[53] Hartsock, N. J., Mueller, T. G., Thomas, G. W., Barnhisel, R. I., Wells, K. L. and Shearer, S.A. (2000). Soil electrical conductivity variability. In: Robert, P.C. et al. (Eds.) Proc. 5th international conference on precision Agriculture. ASA Misc. Publ., ASA, CSSA, and SSSA, Madison, WI.

[54] Brady, N.C. and Weil, R.R. (2002). The nature and properties of soils.13th ed. Prentice-Hall, Upper Saddle River, NJ 07458.

[55] Gregorich, E.G., Carter, M.R., Anger, D.A, Monreal, C.M. and. Ellert, B.H. (1994). Towards a minimum data set to assess soil organic matter quality in agricultural soils. Canadian Journal of Soil Science 74,367-385.

[56] Petrovic, A.M. (1990). The fate of nitrogenous fertilizers applied to turfgrass. Journal Environmental Quality 19,1–14.

Received: August 18, 2008
Accepted: December 03, 2008

CORRESPONDING AUTHOR

Turan Yüksek
Artvin Coruh University
Faculty of Forestry
08000 Artvin
TURKEY

E-mail: turan53@yahoo.com

FEB/ Vol 18/ No 5b/ 2009 – pages 848 - 857

UBYT Dergi Listesi Tarama Motoru

Aranacak: ve -- Dergi Grubu -- ve -- İndeks Türü -- 2009
Ara Yardım

Tarananlar: {'**FRESENIUS**', '**ENVIRONMENTAL**', '**BULLETIN**'}@Anahtar; {'**2009**'}@Yayın Yılı, Sayfa: **1**

No	Dergi Adı	Dergi Kısa Adı	ISSN	Dergi Grubu	Yayın Yılı	İndeks Türü
1.	**FRESENIUS ENVIRONMENTAL BULLETIN**	FRESEN ENVIRON BULL	1018-4619	C	2009	Fen (SCI)

© 2008 TÜBİTAK-ULAKBİM

Journal Search

Search Terms: FRESENIUS ENVIRONMENTAL BULLETIN

Total journals found: 1

The following title(s) matched your request:

Journals 1-1 (of 1)

FORMAT FOR PRINT

FRESENIUS ENVIRONMENTAL BULLETIN
Monthly
ISSN: 1018-4619
PARLAR SCIENTIFIC PUBLICATIONS (P S P), ANGERSTR. 12, FREISING, GERMANY, 85354
Coverage
Science Citation Index Expanded
Current Contents - Agriculture, Biology & Environmental Sciences
Zoological Record

Journals 1-1 (of 1)

FORMAT FOR PRINT

© 2009 Thomson Reuters