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# Soil Chemical Differences Between Pasture Types in Southern Marmara, Turkey

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In this study, the effects of soils on poor yield and condition of pastures in Southern Marmara, Turkey were determined. For this reason, total of 60 soil samples, in Spring 2006, were collected from 5 types of pastures in Canakkale, Balikesir and Bursa provinces, all located in the Southern Marmara region. Pasture types investigated were mountain, shrubland, coastal, lowland and forest gap type pastures. All of the collected soil samples were being evaluated for soil electrical conductivity (EC), pH, CaCO3, P, K, Ca, Mg, Na, Fe, Mn, Zn, Cu and organic matter. The EC (P = 0.000), $CaCO_3$ (P = 0.009), organic matter (P = 0.000), P (P = 0.003), K (P = 0.027), Fe (P = 0.025) and Cu (P = 0.047) levels of soils were significantly different between pastures. Highest levels of EC (1.67 ± 0.82 dS $m^{-1}$) and of $CaCO_3$ (5.81 ± 1.02 %), were found in the soil samples obtained from coastal region and shrubland type pastures, respectively. However, the highest levels of both organic matter (4.94 ± 0.50 %) and P (49.0 ± 3.4 ppm) were found in both forest gap and lowland type pastures. Cu level was the highest in coastal type pastures among all 5 types of pastures analyzed. Among the provincial pastures, pH (P = 0.009), organic matter (P = 0.007), P (P = 0.002), Ca (P = 0.019), Mg (P = 0.020), Fe (P = 0.000), Zn (P = 0.013) and Cu (P = 0.003) levels of soils were significant. The highest levels of pH (7.40 ± 0.11), of $CaCO_3$ (4.87 ± 0.61 %), of Ca (3049 ± 275 ppm) and of Mg (656.7 ± 60.9 ppm) level were found in pastures of Canakkale province while the highest levels of organic matter (%4.01 ± 0.40), of Fe (22.8 ± 3.0 ppm), of Zn (1.21 ± 0.10) and of Cu (0.92 ± 0.08 ppm) were found in pastures of Bursa province. Overall results of this study indicated that pastures of Southern Marmara region do not have very significant problem in their soil chemical compositions. Therefore, in order to improve these pastures, prescribed grazing management or weed/vegetation management practices should be applied.

**Key Words: Soil minerals, Pasture Types, Southern Marmara.**

## INTRODUCTION

Southern Marmara region covers most of Northwestern corner of Turkey and it has the highest population density among all regions in Turkey. Pastures in this region cover only 4.5 % of the land. However, average pasture coverage

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is 15.9 % throughout Turkey[1]. While area of pasture is shrublands and forest gaps which are not considered as pasture are used with grazing. Livestock production and yield in the region are at a better status compared to the other regions. On the other hand, pastures are not sufficiently used. Especially the pastures are grazed limited with high milk yielded cows.

Pastures of this region are varied since they are topologically diverse which means it comprises shorelands, plains and mountainous regions. Archer and Smeins[2] stated that this topology causes diversity both in climate and soil that are the major ecologic factors affecting the vegetations of pastures. Soil chemical characteristics are one of the indicators of vegetation productivity and its diversity. Soil organic matter content is an important source of nutrient and it affects soil physical characteristics. According to Hodges[3] and Johnston[4] a positive linear correlation between the soil productivity and its organic matter is found. Organic matter also increases soil microbial activity which will enhance the bioformation of minerals[5]. Soil pH affects the root development of plants[6] and mineral availability[5,7,8] to plants. Soil salt content affects the morphology and metabolism of plants[9] and excess salty soils cause developmental delays in plants[10,11]. Sudden salt stress may cause chlorotic and necrotic phenotype in naturally non-salt-tolerant plants, eventually yield reduction or even loss of entire vegetation may be observed[12].

Salt problem is generally observed in coastal type pastures in addition to arid lands but not in others[13,14]. Mineral contents of soils affect the uptake of minerals by plants[15]. Plant species in a vegetation use different levels of minerals. For example, legumes use P and K most efficiently while grasses use N most efficiently[16]. A study involving seven plant species (*Agropyron cristatum, Bromus tomentellus, Festuca ovina, Koeleria cristata, Stipa lagascea, Medicago varia* and *Teucrium polium*) demonstrated both *B. tomentellus* and *F. ovina* (grasses) contain the highest amount of P while *M. varia* (legume) contains the highest amounts of the K, Ca and Mg[17].

Chemical compositions of pasture soils are affected by topography (which changes among the geographical regions), bedrock, climate (mainly rain and temperature), physical and mechanical factors. The result of all of these forces is the pasture soil shapes the vegetation[18] and organic matter contents of pastures. For example, shrubland type pastures accumulate more organic carbon compared with forest (of coniferous trees) type pastures[19].

In this study, chemical compositions of 5 types of pasture soils, from Canakkale, Balikesir and Bursa provinces which locate in the Southern Marmara region of Turkey, were analyzed and then chemical composition differences and similarities among the soils of 5 pasture types and of 3 provinces (which are Canakkale, Balikesir and Bursa) were statistically evaluated. Additionally, relationships among chemical component of soils analyzed within each province were evaluated by Pearson correlations.

## EXPERIMENTAL

Experiments were conducted in 2006 on the pastures of the Bursa, Balikesir and Canakkale provinces located in the Southern Marmara Region of Turkey. In experimental year, average rainfall was 482.9, 503.8 and 591.4 mm in Canakkale, Balikesir and Bursa, respectively, less than the long term average (*ca.* 70 years) of 615.6, 562.7 and 699.0 mm, respectively, while average day temperature was 14.7, 13.8 and 14.4 ºC in Canakkale, Balikesir and Bursa, respectively, very close to long term average of 14.8, 14.6 and 14.8 ºC, respectively.

**Pasture types:** Types of pastures considered in this research are grouped based on their topographic and geographical characteristics such as mountain, shrubland, coastal, forest gab and lowland pastures[20]. For example, mountain type pastures are geographically uneven and are covered with species such as *Dactylis glomerata, Lolium rigidum, Bromus tectorum, Bromus hordeaceus, Catabrosella parviflora, Trifolium angustifolium, Genista anatolica, Plantago lagopus* and *Crepis sancta*[21].

Shrubland type pastures are diverse topographically which means they are observed both on plains and on hilly lands. These pastures, typically, are covered by Mediterranean specific plant communities such as *Paliurus spina-cristi, Quercus coccifera, Sarcopoterium spinosum, Cistus creticus, Phillyrea latifolia* that are the most common shrub species. Additionally, *Aegilops ovata, Bromus tectorum, Vulpia ciliata, Lolium rigidum* and *Dactylis glomerata* are the most commonly observed herbaceous plant species of these pastures.

Coastal pastures are on the sandy and/or salty plains and mostly consist of plant species such as *Dactylis glomerata, Lolium rigidum, Cynodon dactylon, Cynosurus echinatus, Hordeum murinum, Medicago marina, Eryngium campestre, Centaurea solstitialis* and *Carduus nutans*.

Lowland pastures are on the plains and/or on lands that remain few centimeters above ground-water level. Plant composition of these pastures may include species such as *Dactylis glomerata, Lolium rigidum, Cynodon dactylon, Cynosurus echinatus, Hordeum murinum, Eryngium campestre, Centaurea solstitialis* and *Carduus nutans*.

Forest gap type pastures are on the land patches within forests and their vegetation mostly includes species such as *Dactylis glomerata, Lolium rigidum, Poa* spp., *Phleum* sp., *Taeniatherum caput-medusa, Genista anatolica, Hypericum* spp. and *Pteridium aquilinum*.

**Soil sampling:** As representing regional pastures, total of 60 soil samples in 0-20 cm soil depth were collected randomly[22] from 5 types of pastures (which include mountain type pastures, shrubland type, coastal pastures, lowland pastures and forest gap pastures) during spring 2006 and then kept in refrigerator until their chemical compositions analysis.

Number of collected soil samples from each province and from different pastures were listed at Table-1. The collection sites of soils located close to Marmara and Aegean Sea, which typically have common Mediterranean climate.

TABLE-1
DISTRIBUTION OF SOIL SAMPLES WITHIN THE PASTURE TYPES AND WITHIN THE PROVINCES

| Pasture types | Çanakkale | Balikesir | Bursa | Soil sample # |
|---|---|---|---|---|
| Mountain | 5 | 4 | 6 | 15 |
| Shrubland | 14 | 1 | - | 15 |
| Coastal | 4 | - | - | 4 |
| Lowland | 5 | 6 | 5 | 16 |
| Forest gap | 2 | 1 | 7 | 10 |
| Soil sample # | 30 | 12 | 18 | Total = 60 |

**Laboratory analysis:** Chemical analysis of collected soils included electrical conductivity (EC), pH, $CaCO_3$, organic matter, P, K, Ca, Mg, Na, Fe, Mn, Zn and Cu content measurements. EC was measured using electrical conductivity testing machine after dilution of soil samples at a 1:2.5 soil: water (v:v) ratio[23]. Soil reaction (pH) was measured[24] using pH meter in a solution of 1:2.5 v:v soil:water. $CaCO_3$ content was measured by a Scheibler Calcimeter method[25]. Organic matter content was determined with minor modification of wet combustion (Walkey-Black) method[22]. Available phosphate level in soil was determined[26] by introduction of 0.5 M sodium bicarbonate solution (pH 8.5). Exchangeable Na and K were extracted[27] with 1 N-ammonium-acetate (pH = 7) and measured using flame photometer. Exchangeable Ca and Mg in soil were determined using atomic absorption spectrophotometry[28]. Available $Fe^{2+}$, $Cu^{2+}$, $Zn^{2+}$ and $Mn^{2+}$ were extracted[29] with 0.005 M DTPA-TEA and measured using AAS.

**Statistical analysis:** One-way-ANOVA was used to compare soil chemical characteristics of pastures types and of provinces. Differences among the pasture types and among the provinces were determined using Duncan multiple range test. Correlations between the soil chemical characteristics were determined using Pearson correlation[30]. All the analysis including ANOVA, Duncan multiple range test and Pearson correlations were performed using MINITAB statistical software (version 13.0 for Windows) of Minitab Inc.

## RESULTS AND DISCUSSION

Soil chemical characteristics including EC (P = 0.000), $CaCO_3$ (P = 0.009), organic matter (P = 0.000), P (P = 0.003), K (P = 0.027), Fe (P =

0.025) and Cu (P = 0.047) were significant among the soils of different pasture types. Coastal pastures contained the highest levels of salt (EC = 1.67 ± 0.82 dS $m^{-1}$) among all analyzed pasture soils as expected since they are close to sea and accumulation of salt crystals that are carried with wind from sea and/or from rising ground water are observed[31]. Rest of the pasture soils in this study contained similar levels of salt (Table-2).

TABLE-2
MEANS AND STANDARD ERRORS (SE) OF SOIL CHEMICAL CHARACTERISTICS AND THE CORRESPONDING PASTURE TYPES

| Soil chemical characteristics | Mountain | Shrubland | Coastal | Lowland | Forest Gap |
|---|---|---|---|---|---|
| | Mean±SE | Mean±SE | Mean±SE | Mean±SE | Mean±SE |
| EC (dS $m^{-1}$) | 0.19±0.02b | 0.17±0.01b | 1.67±0.82a | 0.21±0.03b | 0.16±0.02b |
| pH | 6.99±0.13 | 7.49±0.15 | 7.59±0.26 | 7.02±0.16 | 7.06±0.19 |
| $CaCO_3$ (%) | 3.30±0.68ab | 5.81±1.02a | 4.12±0.60ab | 2.57±0.30b | 2.95±0.39ab |
| Org. matter (%) | 2.39±0.31b | 2.34±0.17b | 3.34±0.75ab | 4.41±0.32a | 4.94±0.50a |
| P (ppm) | 35.8±3.0ab | 28.1±3.9b | 45.2±11.6ab | 45.9±4.0a | 49.0±3.4a |
| $K^+$ (ppm) | 159.2±18.3b | 207.8±15.9ab | 206.8±22.0ab | 230.6±15.9a | 168.1±20.8ab |
| $Ca^{2+}$ (ppm) | 2256±296 | 3193±432 | 2693±628 | 2333±258 | 2531±382 |
| $Mg^{2+}$ (ppm) | 558.5±59.3 | 585.7±78.3 | 626.0±190.0 | 656.4±86.0 | 311.2±72.3 |
| $Na^+$ (ppm) | 41.5±5.0 | 38.0±4.7 | 66.3±28.4 | 39.0±3.8 | 31.1±6.6 |
| $Fe^{2+}$ (ppm) | 16.5±3.4ab | 7.8±1.4b | 15.0±1.3ab | 22.1±3.5a | 17.7±4.2ab |
| $Mn^{2+}$ (ppm) | 12.3±1.6 | 12.1±1.8 | 17.0±2.4 | 15.1±1.7 | 14.8±2.3 |
| $Zn^{2+}$ (ppm) | 0.85±0.08 | 0.79±0.13 | 0.89±0.23 | 1.09±0.10 | 1.20±0.14 |
| $Cu^{2+}$ (ppm) | 0.69±0.11ab | 0.75±0.14ab | 1.29±0.20a | 0.49±0.11b | 0.68±0.11ab |

The differences among the pasture types designated with different letters are statistically significant ($p < 0.05$).

Levels of $CaCO_3$ were different between shrubland (5.81 ± 1.02 %) and lowland type (2.57 ± 0.30 %) pastures (Table-2). Shrubland pastures have more shallow soils compared with lowland pastures and the bedrocks underlying the shrubland pastures of this study are composed of $CaCO_3$, mainly limestone[32].

Highest levels of organic matter content were found in both forest gap pastures (4.94 ± 0.50%) and lowland pastures (4.41 ± 0.32 %). However, the lowest levels of organic matter content were found at both shrubland (2.34 ± 0.17 %) and mountain pastures (2.39 ± 0.31 %).

Source of organic mater (*ca.* 99 %) is phytomass[33]. Composition of forest vegetation including trees, shrubs and grass species contributes greatly into organic matter content of forest gap pastures. Lowland pastures are mostly supported by runoff water and by soil erosion and therefore they have deeper soils which hold more water and for very long time. More abundant vegetation is observed in lowland type pastures but not in mountain type pastures and shrubland pastures. Therefore, organic matter content is highest in lowland pastures compared with mountain and shrubland pastures.

As observed in organic matter content, the levels of P, K and Fe (45.9 ± 4.0, 230.6 ± 15.9 and 22.1 ± 3.5 ppm, respectively) were also high in lowland type pastures. Among the 5 types of pastures, highest levels of P (49.0 ± 3.4 ppm) was found in forest gap type soils while the lowest levels of P, K and Fe were found in shrubland and mountain type pasture soils (Table-2). Since lowland pastures from accumulations of run-off water and nutrients and since both forest gap and lowland pastures contain the highest levels of organic matter, mineral compositions of these two types of pastures are rich. Organic matter improves the soil water holding capacity and mineral contents of soils[34]. For example, a study demonstrated[35] 1 % increase in soil organic matter reduces the soil erosion 10 %. Another study demonstrated[36] an increase of soil organic matter increases the cation exchange capacity of the soils.

Cu composition differences were only observed between the coastal (1.29 ± 0.20 ppm) and lowland type pasture (0.49 ± 0.11 ppm) soils (Table-2). Increasing pH levels of soils reduce Cu absorption by plants[37]. Hence, increasing Cu levels may be observed. Coastal pastures contained the highest levels of Cu and of pH (7.59 ± 0.26) among all pasture types in this study. Soil Cu deficiency is observed in soils with high levels of organic matter[37]. High organic matter containing lowland pastures contained low levels of Cu in this study as a negative correlation between Cu and organic matter content of soils was reported earlier[37].

Evaluations of soil chemical characteristics among the three provincial pastures (Canakkale, Balikesir and Bursa) demonstrated organic matter content ($P = 0.007$), pH level ($P = 0.009$), contents of minerals including P ($P = 0.002$), Ca ($P = 0.019$), Mg ($P = 0.020$), Fe ($P = 0.000$), Zn ($P = 0.013$) and Cu ($P = 0.003$) are significant among the provincial pastures. In the Fe and $CaCO_3$ content and in pH levels of soils, only Canakkale and Balikesir pasture soils were different from each other while in the mineral contents (which include P, Ca, Mg, Fe and Zn) and in organic matters of soils, Canakkale and Bursa pastures were different (Table-3).

As the differences among the chemical compositions of the provincial pastures may originate from the differences in climate and in vegetation of provincial pastures, these differences may also originate from the existence and distribution of different pasture types within each province. For example, in Canakkale province, shrublands are common while in the Bursa province, forest gap pastures are common (Table-1). In conclusion, chemical composition differences that have been observed among the provincial pastures in this study, may be due to the existing chemical characteristic differences among the different types of pasture soils.

TABLE-3
MEANS AND STANDARD ERRORS (SE) OF PROVINCIAL SOIL CHEMICAL CHARACTERISTICS

| Soil chemical characteristics | Canakkale Mean±SE | Balikesir Mean±SE | Bursa Mean±SE |
|---|---|---|---|
| EC (dS $m^{-1}$) | 0.37±0.14 | 0.21±0.03 | 0.19±0.02 |
| pH | 7.40±0.11a | 6.85±0.17b | 7.01±0.12ab |
| $CaCO_3$ (%) | 4.87±0.61a | 1.73±0.09b | 3.15±0.31ab |
| Organic matter (%) | 2.77±0.26b | 4.00±0.37ab | 4.01±0.40a |
| P (ppm) | 32.60±2.9b | 43.10±3.7ab | 48.20±3.3a |
| $K^+$ (ppm) | 187.30±12.1 | 236.90±19.1 | 180.00±15.8 |
| $Ca^{2+}$ (ppm) | 3049.00±275a | 2173.00±314ab | 2089.00±160b |
| $Mg^{2+}$ (ppm) | 656.70±60.9a | 515.10±55.9ab | 411.10±61.4b |
| $Na^+$ (ppm) | 39.60±5.1 | 44.50±5.5 | 37.20±3.6 |
| $Fe^{2+}$ (ppm) | 9.40±1.2b | 22.00±4.4a | 22.80±3.0a |
| $Mn^{2+}$ (ppm) | 13.40±1.2 | 12.40±2.3 | 15.10±1.5 |
| $Zn^{2+}$ (ppm) | 0.84±0.08b | 0.88±0.11ab | 1.21±0.10a |
| $Cu^{2+}$ (ppm) | 0.69±0.09ab | 0.34±0.11b | 0.92±0.08a |

The differences among the provinces designated with different letters are statically significant ($p < 0.05$).

Pearson correlation coefficients were calculated in order to determine the relationships between any two chemical characteristics of Canakkale, Balikesir or Bursa provincial soil samples (Table-4). Most of the Pearson correlations between any two chemical characteristics of a provincial soil sample were found not significant (Table-4). However, within Canakkale provincial soil samples, EC with P and Na; pH with $CaCO_3$, K, Fe and Mn; $CaCO_3$ with organic matter and Fe; organic matter with P and Fe; Ca with Fe and Mn; Fe with Mn and Zn were correlated significantly, within Balikesir provincial soil samples, EC with pH; pH with Ca and Fe; $CaCO_3$ with K; Na with Zn; Mn with Cu were correlated significantly.

Pearson correlation calculations of Bursa provincial soil chemical characteristics determined EC with pH and $CaCO_3$; pH with $CaCO_3$, Ca with Fe; $CaCO_3$ with Ca, Fe and Cu; organic matter with K, Na and Zn; Na with Zn; K with Ca and Cu; Mg with Fe correlates well. Another observation of this study was correlations between soil chemical characteristics are different for different provincial samples. This may be originated from the uneven number of samples taken from each province and also from existence of different pasture types within each province. On the other hand, a positive correlation between pH and EC[38]; $CaCO_3$ and Ca are known. Because $CaCO_3$, Ca and the minerals that salty soils contain, have basic characteristics, as these minerals increase in soils an increase of pH levels are expected. The present results confirm the results of Kalbasi *et al.*[39] who demonstrated a negative correlation between pH and Fe since a negative correlation between the pH and Fe levels was observed in present provincial soil analysis (Table-4).

TABLE-4
PEARSON CORRELATION COEFFICIENTS BETWEEN SOIL CHEMICAL CHARACTERISTICS OF CANAKKALE, BALIKESIR AND BURSA PROVINCES SAMPLES

| Char. | EC | pH | $CaCO_3$ | Org. matter | P | $K^+$ | $Ca^{2+}$ | $Mg^{2+}$ | $Na^+$ | $Fe^{2+}$ | $Mn^{2+}$ | $Zn^{2+}$ |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Canakkale** | | | | | | | | | | | | |
| pH | 0.306 | | | | | | | | | | | |
| $CaCO_3$ | -0.032 | 0.559‡ | | | | | | | | | | |
| Org. matter | 0.258 | -0.253 | -0.409† | | | | | | | | | |
| P | 0.427† | -0.311 | -0.273 | 0.591‡ | | | | | | | | |
| $K^+$ | 0.244 | 0.521‡ | 0.216 | -0.140 | -0.131 | | | | | | | |
| $Ca^{2+}$ | -0.156 | 0.330 | 0.206 | -0.093 | -0.170 | 0.039 | | | | | | |
| $Mg^{2+}$ | 0.021 | -0.051 | -0.115 | -0.057 | -0.037 | 0.129 | 0.086 | | | | | |
| $Na^+$ | 0.465‡ | 0.214 | 0.129 | -0.097 | 0.016 | 0.249 | -0.358 | 0.305 | | | | |
| $Fe^{2+}$ | 0,307 | -0.481‡ | -0.409† | 0,631‡ | 0.504‡ | -0.086 | -0.459† | 0.149 | 0.318 | | | |
| $Mn^{2+}$ | 0.066 | -0.413† | -0.285 | 0.162 | 0.163 | -0.192 | -0.379† | -0.146 | 0.040 | 0.502‡ | | |
| $Zn^{2+}$ | 0.032 | -0.292 | -0.125 | 0.444† | 0.313 | -0.339 | -0.120 | -0.116 | -0.011 | 0.379† | 0.049 | |
| $Cu^{2+}$ | 0.299 | 0.287 | 0.334 | -0.162 | -0.089 | 0.248 | -0.120 | -0.205 | 0.297 | -0.035 | -0.152 | 0.178 |
| **Balikesir** | | | | | | | | | | | | |
| PH | 0.636† | | | | | | | | | | | |
| $CaCO_3$ | -0.361 | -0.329 | | | | | | | | | | |
| Org. matter | 0.489 | 0.183 | -0.448 | | | | | | | | | |
| P | -0.157 | -0.230 | 0.245 | -0.314 | | | | | | | | |
| $K^+$ | 0.151 | 0.524 | -0.667† | 0.139 | -0.304 | | | | | | | |
| $Ca^{2+}$ | 0.497 | 0.736‡ | -0.362 | 0.101 | -0.453 | 0.367 | | | | | | |
| $Mg^{2+}$ | -0.098 | -0.330 | -0.243 | 0.244 | 0.079 | -0.273 | -0.059 | | | | | |
| $Na^+$ | 0.241 | 0.126 | 0.037 | 0.062 | 0.428 | -0.230 | -0.204 | -0.198 | | | | |
| $Fe^{2+}$ | -0.521 | -0.862‡ | 0.252 | -0.078 | 0.276 | -0.533 | -0.552 | 0.168 | -0.019 | | | |
| $Mn^{2+}$ | -0.412 | -0.301 | -0.197 | -0.232 | 0.519 | 0.283 | -0.504 | 0.198 | -0.242 | 0.191 | | |
| $Zn^{2+}$ | -0.125 | -0.137 | -0.284 | 0.268 | -0.351 | 0.262 | -0.099 | 0.420 | -0.653† | -0.179 | 0.319 | |
| $Cu^{2+}$ | 0.133 | -0.267 | -0.053 | -0.125 | 0.482 | -0.173 | -0.521 | 0.237 | 0.149 | 0.145 | 0.580† | 0.001 |
| **Bursa** | | | | | | | | | | | | |
| pH | 0.508† | | | | | | | | | | | |
| $CaCO_3$ | 0.631‡ | 0.739‡ | | | | | | | | | | |
| Org. matter | 0.017 | 0.016 | 0.287 | | | | | | | | | |
| P | 0.005 | -0.076 | 0.202 | 0.094 | | | | | | | | |
| $K^+$ | 0.270 | 0.148 | 0.353 | 0.560† | 0.390 | | | | | | | |
| $Ca^{2+}$ | 0.268 | 0.636‡ | 0.488† | 0.348 | 0.001 | 0.307 | | | | | | |
| $Mg^{2+}$ | 0.181 | -0.084 | -0.290 | 0.022 | -0.463 | 0.239 | 0.028 | | | | | |
| $Na^+$ | 0.400 | -0.086 | -0.067 | -0.479† | -0.229 | -0.245 | -0.213 | 0.294 | | | | |
| $Fe^{2+}$ | -0.461 | -0.633‡ | -0.565† | 0.218 | 0.012 | 0.337 | -0.310 | 0.470† | -0.033 | | | |
| $Mn^{2+}$ | 0.062 | -0.031 | 0.154 | 0.071 | 0.038 | 0.066 | -0.269 | -0.338 | 0.024 | -0.068 | | |
| $Zn^{2+}$ | 0.193 | 0.148 | 0.267 | 0.684‡ | -0.003 | 0.433 | 0.122 | 0.173 | -0.314 | -0.015 | 0.349 | |
| $Cu^{2+}$ | 0.348 | 0.405 | 0.582† | 0.237 | 0.178 | 0.477† | 0.583† | -0.177 | -0.239 | -0.324 | 0.208 | 0.219 |

Char. = Characteristics; †$p < 0.05$, ‡ $p < 0.01$.

Among the 5 types of pasture soils analyzed from the Southern Marmara region, only the coastal pasture soils have salinity problem. Soil pH is considered neutral and $CaCO_3$ levels are at medium level for the analyzed soil samples. Among all provinces, Balikesir pastures contained the lowest levels of $CaCO_3$. Both Balikesir and Bursa provincial soils were rich in organic matter while Canakkale provincial soils contained the medium levels of organic matter.

Among all pasture types, both mountain and shrubland type pastures contain the medium levels of organic matter while the lowland and forest gap pastures contain the highest levels of organic matter. None of pasture types in this study have deficiencies in levels of K, Ca, Fe, Zn and Cu minerals but the levels of P are in excess amount in all pasture soils. Levels of Mg are enough in soils of forest gap pasture and Bursa provincial pastures, however, their levels are in excess amount in rest of soil samples regardless of the provincial type or pasture types. Levels of Na are normal in provincial pasture type soils. Sufficient levels of Mn are observed in both mountain and shrubland pasture types. Additionally, Canakkale and Balikesir provincial pastures contain the low levels of Mn while the Bursa pastures contain the Mn at sufficient levels.

Management and ecological factors affect yield and quality of pastures. The most effective factors among ecological factors are undoubtedly soil and climatic factors. In three provinces in where the study was conducted, climate and especially rainfall were not limited factors for plant growth. In addition, the results here indicate that Southern Marmara region pastures do not have any significant problem with respect to soil chemical properties. Organic and inorganic contents in the soils were sufficient enough for productivity of the pastures. Despite sufficient ecological factors for plant growth, the pastures (especially mountain, coastal and shrubby areas) in the regions are at poor and moderate status. This could be attributed to mismanagement of these pastures. Secondary succession in pastures will speedily occur if there is sufficient rainfall and soil without any problem. As ecological factors were suitable for secondary succession, appropriate grazing methods or weed/vegetation management practices could be the solution for rapid pasture amendment and maintaining a longer productivity.

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