VARIATION OF DEHIDROGENASE ENZYME AKTIVITY AND DIFFERENT PEDOGENETIC DEVELOPMENT ON WEATHERED BASALTIC TOPOSEQUENCES

Aylin Erkoçak[1], Orhan Dengiz[2]

[1]Black Sea Agricultural Research Institute, Samsun, Turkey
[2]Faculty of Agriculture, Ondokuz Mayis University, Samsun, Turkey

Corresponding author: aylinerkocak@gmail.com

Abstract
Enzymes play the most important role in the decomposition and deterioration of organic matter in the soil. Most of the microbial activity in the soil is determined by measuring the activities of the enzymes. The aim of this study is to examine the changes in dehydrogenase enzyme activity in different pedological development soils formed on the same parent material, but with different slopes, land cover and land use under semihumid climatic conditions. It was carried out on the soil formed on the basaltic parent material in different topographical positions within the Dağköy area of Engiz district, which is located at the south of the Samsun-Bafra Highway. In this study, dehydrogenase enzyme activity was assessed in order to reveal the biological properties of the soil of the study area and it was investigated the dehydrogenase enzyme activity in terms of soil biological property. For this aim, six soil profiles formed on weathered basaltic parent material and located on toposequence of north-south transect were described according to genetic horizon and classified as Lithic Ustorthent, Vertic Haplustept, Typic Haplustept and Typic Haplustert. It was determined that the dehydrogenase changed between 0.073-1.170 µg TPF in soils taken from each profiles. In addition, when the statistical relationship between dehydrogenase enzyme activity and different profiles, land use, and height along the north-south transect was investigated different profiles and different heights were found to be important at % 1 level of effect on dehydrogenase enzyme activity in the soil ($P=0.006<0.01$). Also the effect of different land use patterns were found to be important at % 5 level on the activity of dehydrogenase enzyme in the soil ($P = 0.048<0.05$).

Keywords: Soil microorganisms, dehydrogenase enzyme activity, pedogenesisi, toposequence.

Introduction

Soil microorganisms actively participate in many processes such as mineralization of plant and animal wastes added to soils and biochemical transformation of plant nutrients and also have important effects on soil fertility (Alexander, 1977). For this reason, soil fertility is not only related to the physical conditions and the level of nutrients of the soil, but also the intensity of biological events.

The studies until today reveal that the quality of the soil, the level of fertility and measures to be taken in terms of plant nutrition and the issues related with physical, chemical, biochemical, microbiological, mineralogical, zoological and plant physiology of soil should be considered together (Schinner, 1986). Determination of the biological properties of soils is based on the principle of measuring the activities of microorganisms together with the number and distribution of microorganisms in the soil (Gök ve Onaç, 1995). The food cycle in the soil involves biochemical, chemical and physicochemical reactions and many biochemical events through Soil organisms, plant roots and soil enzymes originating from microorganisms are carried out (Tabatabai, 1982). In this respect, while investigating the microbiological characteristics of soils, the products formed as a result of microbial activity and enzymes secreted during activity are also measured besides of the number and distributions of microorganisms in the soil (Müller, 1965). Dehydrogenase activity, one of the enzymes used in determining the biological properties of soils, is an intracellular enzyme (Trevors, 1984) found in living microbial cells in the soil and it is an indicator used in the assessment

of microbial activity in the soil (Garcia ve ark., 1994). Thus, dehydrogenase activity is a marker of biological redox systems and is used as a measure of the density of microbial metabolism in the soil (Okur, 1997).

The aim of this study is to examine the changes dehydrogenase enzyme activity in soils developed on the weathered basaltic toposequence. Soils formed on the same parent material on the other hand, they founded on different physographical units and land cover-land uses under semihumid climatic conditions within the Dağköy area of Engiz district, which is located at the south of the Samsun-Bafra Highway. Therefore, this paper presents also effects of pedogenesis development, topographic changing, elevation, variation of land cover and land use on dehydrogenase enzyme activity.

Material and methods

General Definition of The Research Field

This study was carried out in the south eastern part of the Samsun-Bafra Plain located in the Kızılırmak Delta in the central Black Sea Region of Turkey (Figure. 1). The study area is located approximately 20 km west of the Samsun provincial centre (4594000-4598000 N, 751000-758000 E, UTM/WGS 84 m).

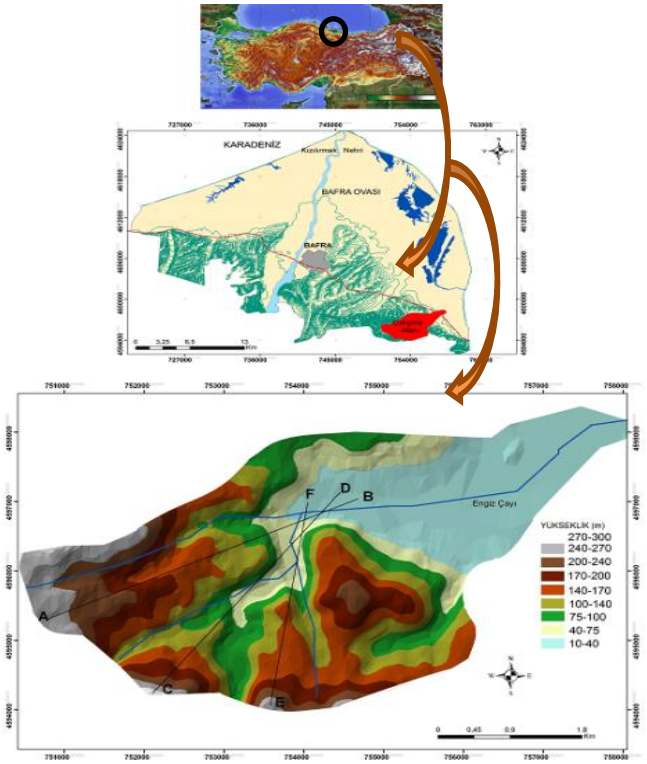


Figure 1. Location map of the study area and cross section with elevation

The Engiz Brook plays a major role in the formation and development of the landscape. Considered, in the soils formed on the basalt parent material there are pastureland and dry farming lands.In addition, only small part of the study area has been covered by forest land. Some forest land was also degraded due to misuse applications. The current climate in the region is semi-humid. The coldest month of the year is February in the study area (5.6 ºC) whereas, the hottest months are July and August (22.6 ºC). The mean annual temperature, rainfall and evaporation are 13.6ºC, 764.3 mm and 726.7 mm, respectively.

The profile pits lacation were determined by the preliminary field excursion and office works with base data evaluation such as geological, topographical and land use land cover maps after that filed work using the GPS tool in order to determine profile coordinates in the study area, profile pits were excavated defined points in field. Soil samples were taken from each horizon of profiles and brought

to the laboratory. After pre-treatment process of soil samples, physical, chemical and biological analyses were performed. Morphological studies were carried out in the field using Soil Survey Staff (1993).

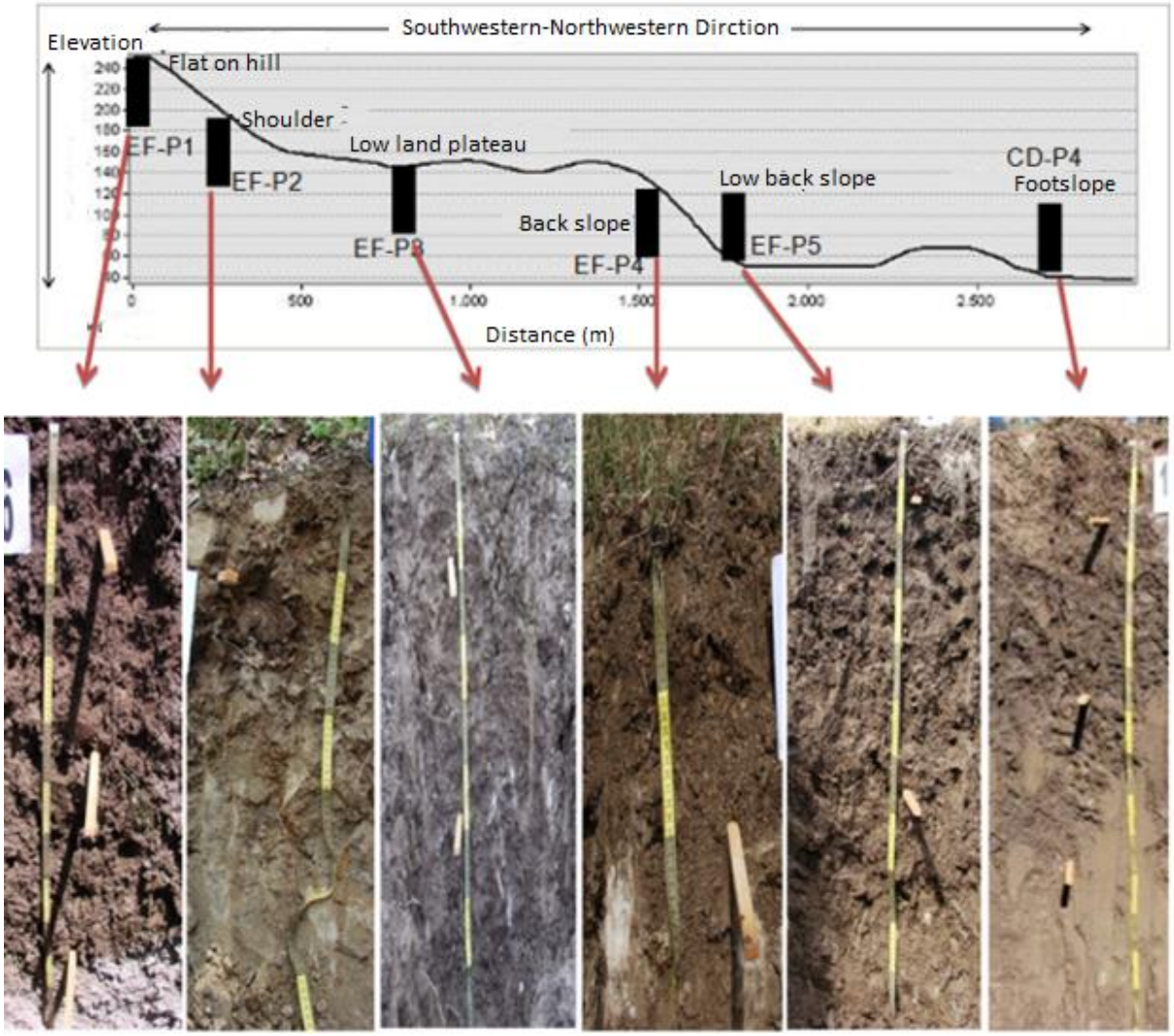


Figure 2. Transect of the four different soil profiles on the same parent material but different topographic positions

Physical, Chemical and Biological Analyzes

Texture: in disturbed soil samples (Bouyoucos, 1951); Cation exchange capacity: using sodium acetate (NaOAc) adjusted to pH 8.2 and 1 N ammonium acetate (NH4OAc) (Rhoades, 1986), Exchangeable cations (Na and K): using ammonium acetate (NH4OAc) adjusted to pH 8.2 (Rhoades, 1986), Ca + Mg was determined by the difference between cation exchange capacity and total exchangeable sodium and potassium. Lime; using Scheibler calcimetry in the determination of free carbonates (Soil Survey Staff, 1993), Soil reaction (pH); Using pH meter in saturation mud (Soil Survey Labrotory, 1992, 2004), Electrical conductivity; (Soil Survey Labrotory, 1992, 2004) using a condactivometer instrument in saturation mud, Organic matter was done according to Walkley-Black method by Jackson's modified (Jackson, 1958).

The dehydrogenase enzyme activity of the soils taken from the profiles was determined by Pepper et al. (1995). For this purpose, glucose and 3% TTC (2,3,5-triphenyltetrazolium chloride) solution were added to the soil sample and incubated for 24 hours at 25 °C. TPF (triphenylformazan) formed at the end of incubation was extracted with methanol and the resulting red color intensity was determined on a spectrophotometer at 485 nm versus the standard TPF series. Each analysis was made in 3 parallels and the findings were expressed in µg TPF g-1 dry soil.

Statistical Analysis

SPSS 17.0 package program was used to determine the relationship between dehydrogenase enzyme activity and different profiles, land use and elevation in the soil samples of the study area.

Results and discussion

Physical, Chemical Properties and Classification of Soils in the Study Area

Classification, physiographic position, land use-land cover, elevation, physical and chemical analysis results of different soils (Soil Taxonomy, 1999), located in different topographical positions in the North-South direction are given in Table 1.

Table 1. Classification of the study area soils, physiographic position, land use-land cover, height, physical and chemical analysis results.

Horizon	Depth (cm)	pH	EC dS.m^{-1}	Lime %	Organic Matter %	Exchangeable Cations (cmol.kg^{-1})			Texture %			
						Na^{+}	K^{+}	$Ca^{++}+Mg^{++}$	Clay	Silty	Sand	Class
CD-P4/ Typic Haplustert/ Low footslope/ Dry Agriculture / 20 m												
Ap	0-23	7.50	0.17	0.20	1.65	0.22	1.67	40.19	56.2	23.1	20.7	C
Bss1	23-65	7.30	0.44	0.98	1.26	0.25	1.47	39.64	62.6	12.8	24.5	C
Bss2	65-106	8.25	0.17	1.10	1.09	1.33	1.41	37.59	68.4	15.8	15.8	C
C	106 -146	8.14	0.11	2.67	0.14	1.35	1.40	37.03	78.4	2.8	18.8	C
EF-P5 / Vertic Haplustept / Low backslope / Dry Agriculture/ 50 m												
Ap	0-15	8.28	0.26	0.79	2.21	0.36	0.36	42.97	58.3	20.0	21.7	C
Bw	15-66	8.12	0.18	1.26	0.67	0.47	0.32	42.58	61.9	25.6	12.5	C
2Cr	66-106	8.20	0.25	1.75	0.55	1.02	0.26	26.49	37.3	34.8	27.9	CL
EF-P4 / Lithic Ustorthent / Backslope/ Dry Agriculture/ 135 m												
A	0-19	7.89	0.40	0.39	3.37	0.16	0.49	40.02	32.5	18.6	48.9	SCL
R	19-32	-	-	-	-	-	-	-	-	-	-	-
EF-P3 / Typic Haplustept / Alçak Plato Düzlüğü / Forest /160 m												
A	0-18	7.06	0.44	1.08	1.88	0.24	0.32	46.71	54.4	22.6	23.1	C
Bw	18-57	7.31	0.42	1.02	0.06	0.34	0.09	50.11	61.1	17.7	21.2	C
Cr	57-87	7.01	0.51	0.39	0.57	0.58	0.09	39.87	57.5	22.6	19.9	C
EF-P2 / Lithic Ustorthent / Shoulder / Degraded Forest / 190 m												
A	0-11	6.74	0.35	0.09	1.54	0.35	0.43	27.92	22.0	21.8	56.2	SL
Cr	11-65	7.01	0.20	0.29	0.87	0.54	0.12	17.00	14.6	9.3	76.1	LS
EF-P1 / Vertic Haplustept / Flat on hill / Pasture / 251 m												
A	0-12	7.14	0.55	0.69	3.53	0.29	0.58	48.85	61.9	23.6	14.5	C
Bw1	12-41	7.70	0.54	0.98	1.78	0.27	0.31	43.98	49.9	27.7	12.5	C
Bw2	41-84	7.92	0.11	0.98	1.41	0.64	0.29	51.62	47.9	32.3	19.8	C
2Ck	84-105	7.94	0.38	6.37	1.29	0.63	0.09	43.74	40.0	40.8	19.1	C

EC: Electrical conductivity, OM: Organic matter, C:Clay, Si:Silty, S:Sand

Vertic Haplustept and Typic Haplustept have deep soils due to their formation on gentle slope lands. Their textures are heavy and clay changes between %54.4 and %61.9, %47.9 and %61.9 on the surface soil and the subsurface horizons, respectively. On the other hand, Lithic Ustorthent located on the slope lands has clay content changes between %22.0 and %32.5. The content of organic matter varies between %1.88 and %3.53 in the surface layers of the Vertic Haplustept and Typic Haplustept soils, but this ratios decrease with increasing depth. In Lithic Ustorthent soil, organic matter values change between %1.54 and %3.37. All soil has low contents of lime in the genetic horizons and slightly alkaline reaction. There is no salinity problem in the soils.

Profiles coded as EF-P4 and EF-P2 were characterized as young soils because they do not have a sub-surface diagnostic horizons and were classified in the Entisol order. These soils on sloping lands have particularly shallow soil depth resulted from covered with low vegetation and misapplication farming practices. In this case, these soils do not have enough pedogenetic processes due to

exposure to the resulting erosion. Therefore, there are usually no diagnostic horizons except for a lithic contact in a depth of 50 cm below the surface and ochric epipedone on the surface of these soils. These soils were classified under the Ustorthent and Lithic Ustorthent subordinate due to the moisture regime in the orthent subordinate due to their location on the slope land. On the other hand, due to the fact that profiles coded as EF-P5, EF-P3, EF-P1 and CD-P4 located on the low slope topographical positions such as footslope, low land platuea and falt on hill have more advanced soil formation than the Entisol with the diagnostic horizon (cambic-Bw) and slicensides (Bss). These profiles were classified in Inceptisol order except for CD-P4 that were classified as Vertisol due to slicenside formation. the result is that the soil moisture regime is ustic Ustept subordinate and Haplustept were placed in large group. EF-P5 and EF-P1 were classified as Vertic Haplustept due to their vertical properties on the surface like cruct freatures and also EF-P3 is classified as Typic Haplustept due to their large group properties. In the soil of CD-P4 profile, the amount of swelling clays is too much (along the profile %50 or more), it has cracks extending from the surface in the dry seasons and are placed in the Vertisol order due to the appearance of sliding surfaces in the profile. Due to the ustic moisture regime, it has been placed in the ustert subordinate and in the large group of haplustert and Typic Haplustert subgroup due to the fact that all the properties of the large group are carried.

Biological Properties of Soils in The Study Area

The determined dehydrogenase activity in the soil is an intracellular enzyme has been frequently used in the assessment of the microbiological activity of that soil and it shows the total amount of oxidative activity of soil microflora (Skujins 1973; Trevors 1984; Kızılkaya ve Aşkın, 2006; Aşkın ve Kızılkaya, 2009). Analyzes performed to determine the dehydrogenase enzyme activity of the soils taken from the profiles were carried out in 3 replicates and the results of this analysis are given in Table 2.

Table 2. Concentrations of dehydrogenase enzyme activity characteristics of soil samples taken from the profiles

Horizon	Depth (cm)	Dehydrogenase Activity (µg TPF g^{-1})
CD-P4/ Typic Haplustert/ Low footslope/ Dry Agriculture / 20 m		
Ap	0-23	1.010
Bss1	23-65	1.170
EF-P5 / Vertic Haplustept / Low backslope / Dry Agriculture/ 50 m		
Ap	0-15	0.534
Bw	15-66	0.701
EF-P4 / Lithic Ustorthent / Backslope/ Dry Agriculture/ 135 m		
A	0-19	0.360
EF-P3 / Typic Haplustept / Alçak Plato Düzlüğü / Forest /160 m		
A	0-18	0.819
Bw	18-57	0.073
EF-P2 / Lithic Ustorthent / Shoulder / Degraded Forest / 190 m		
A	0-11	0.147
EF-P1 / Vertic Haplustept / Flat on hill / Pasture / 251 m		
A	0-12	0.840
Bw	12-41	0.332

As a result of dehydrogenase analysis of soil samples taken from each horizon of the profiles, it was determined that the dehydrosine activity that decreased with the soil depths increase were generally lowered in the soil. Dehydrogenase activity is an indicator particularly used in the evaluation of aerobic microorganisms. It is therefore an expected result that high dehydrogenase activity was determined in the surface soil layers due to dominant aerobic conditions. Similarly, Lorenz and Kandeler (2004), Dengiz et al. (2007), Kızılkaya et al. (2007, 2010), Marinari and Antisari

(2010), Antisari et al. (2010), Babu et al. (2010) have also found that topsoil has higher microbial activity.

Relationships between Profile, Land Use, Elevation and Dehydrogenase Enzyme Activity

The results of the biological analysis considered within this study were evaluated statistically using three parameters which are soil profiles, land use-lan cover and the elevation. Results were presented in Table 3.

According to the ANOVA test result, different profiles and different elevation along the North-South direction were found to be important at %1 level of the effect on dehidrogenase enzyme activity from biological properties of soil (P = 0.006 <0.01). According to the DUNCAN test, it was determined that the highest dehydrogenase enzyme activity along the toposequence is in profile coded as CD-P4 and the lowest dehydrogenase enzyme activity is in profile coded as EF-P2. In terms of height, it was determined that the highest dehydrogenase enzyme activity was 25 m high and the lowest dehydrogenase enzyme activity was 190 m high. It was found that the different land use patterns throughout the EF line were significant at 5% level of the effect on dehydrogenase enzyme activity in the soil (P = 0.048 <0.05). It has been determined that the highest dehydrogenase enzyme activity is in dry agriculture areas and the lowest dehydrogenase enzyme activity is in degraded forest soil.

Table 3. Changes in dehydrogenase enzyme activity depending on the profile, elevation and land use of soils taken from the profiles located on the north-south direction

Profiles	Mean + Standard Error	Elevation (m)	Mean + Standard Error	Land Use	Mean + Standard Error
CD-P4	1.01±0.168a	25.00	310.85±8.694a	Dry Agriculture	0.72±0.094a
EF-P5	0.61±0.044ab	50.00	176.27±14.360ab	Degraded forest	0.58±0.114ab
EF-P4	0.36±0.009bc	135.00	88.42±6.714b	Pasture	0.34±0.117b
EF-P2	0.14±0.011c	160.00	193.29±85.496ab	Significant	0.048
EF-P1	0.58±0.114abc	190.00	170.87±6.835ab		
EF-P3	0.45±0.165bc	251.00	194.75±53.277ab		
Significant	0.006	Significant	0.045		

Conclusion

This study was carried out in different pedologically developed soils formed on decomposed basaltic parent material in different topographic positions within the Dağköy area of Engiz district located to the south of Samsun-Bafra highway. In addition, it was examined that the changes of dehydrogenase enzyme activity and soil development under the same parent material, different slope and land use. For this purpose, six profile pits were decribed on the toposequence in the north-south direction. All profiles were defined according to the horizon principle and classified as Lithic Ustorthent, Vertic Haplustep, Typic Haplustept and Typic Haplustert. When the land is examined in terms of the topographic features, it can be said that where the slope is less or low, the developing period of the soil is more advanced level than the places with more slopes due to soil transportation by means of erosion. As a result of the statistical analysis, it was found that different profiles and different elevation along the North-South direction within the basin were significant at %1 level of effect on dehidrogenase enzyme activity from biological properties of soil (P = 0.006<0.01). Different land use forms were found to be significant at %5 level of the effect on dehydrogenase enzyme activity in the soil (P = 0.048 <0.05). In this case, in order to increase procutive ability and to conserve for sustainability of soil, it is necessary not only to take some measurements which can be successful implemented, but also to know and investigate all properties soil in terms of physical, chemical, pedological as well as biological variations. Improving the biological properties as well as the physical and chemical properties in reaching the highest yield power of the soil, which constitutes the main source of plant and animal nutrients, has great importance. For this reason, it is necessary to

concentrate on biologic activities of the soils, that is, applications to increase the natural microbial population and avoid of applications to reduce biological activity. Therefore, the determination of the microbiological and biochemical characteristics of soils with extensive and detailed microbiological studies has a very large importance for the sustainability of agricultural soils.

Acknowledgement
This research was supported by TUBITAK TOVAG project which has 213O073 number. We wish to thank TUBITAK TOVAG for financial support.

References

1. Alexander, M., 1977. Introduction to soil microbiology. 2nd Edition John Wiley. Sons. Inc. New York, USA, 115-147.
2. Antisari, V.L., Marinari, S., Dell'Abate M.T., Baffi, C., Vianello, G., 2010. Plant Cover and Epipedon SOM Stability as Factors Affecting Brown Soil Profile Development and Microbial Activity, Geoderma, 161, 212-224.
3. Aşkın T, Kızılkaya R, 2009. Soil basal respiration and dehydrogenase activity of aggregates: a study in a toposequence of pasture soils. Zemdirbyste-Agriculture 96(1), 98-112.
4. Babu, V.S.M., Parma, V., Kumar, Anıl S., 2010. Enzymes Activities in Soils under Central Dry AgrClimatic Zone of Karnataka, India as Influenced by Soil Depth, Organic and Conventional Management Systems, European Journal of Soil Biology, 3(1), 50-53.
5. Bouyoucos, G.J., 1951. A recalibration of the hydrometer method for making mechanical analysis of soils. *Agronomy Journal* 43, 434-438.
6. Dengiz, O., Kızılkaya, R., Göl, C., Hepşen, Ş., 2007. Effects of Different Topographic Positions on Soil Properties and Soil Enzymes Activities, Asian Journal of Chemistry, 19(3), 2295-2306.
7. Garcia, C., Hernandez T., Costa F., Ceccanti, B., 1994. Biochemical parameters in soils regenerated by the addition of organic wastes. *Waste Management and Research* 12, 457-466.
8. Gök, M., Onaç, I. 1995. "Hilvan ve Baziki Ovalarında Yer Alan Yaygın Toprak Serilerinin Bazı Mikro Biyolojik Özellikleri". Toprak İlmi Derneği İlhan Akalan Toprak ve Çevre Sempozyumu. Ankara.
9. Jackson, M. L. 1958. Soil Chemical Analysis. Englewood Cliffs, New Jersey: Prentice Hall Inc.
10. Kızılkaya R, Aşkın T, 2006. The spatial variability of soil dehydrogenase activity: a survey in urban soils. X.Congress of Croatian Society of Soil Science on Soil Functions in the Environment. June 14-17, 2006. Sibenik, Croatia. Abstract Book (ISBN 953-6135-54-X). p.68.
11. Kızılkaya, R., Dengiz, O., Hepşen, Ş., Başkan, O., 2007. β-Glucosidase Enzyme Activity and Its Relationships with Physico-Chemical Properties in Çatalkaya Basin, Ankara, Ninth Baku International Congress, Energy, Ecology, Economy, 7-9 June, Baku, Azerbaijan.
12. Kızılkaya, R., Dengiz, O., Alpaslan, T., Durmuş, M., Işıldak, V., Aksu, S., 2010. Changes of Soil Microbial Biomass C and Basal Soil Respiration in Different Land Use and Land Cover. International Soil Science Congress on Management of Natural Resources to Sustain Soil Health and Quality, Sayfa: 1039-1046, 26-28 May, Samsun, Turkey.
13. Lorenz, K., Kandeler, E., 2004. Biochemical Characterization of Urban Soil Profiles from Stuttgart, Germany, Soil Biology and Biochemistry, 37, 1373-1385.
14. Marinari, S., Vittori Antisari L., 2010. Effect of Lithological Substrate on Microbial Biomass and Enzyme Activity in Brown Soil Profiles in the Northern Apennines (Italy), Pedobiologia, 53, 313-320.
15. Müller, G., 1965. Bodenbiologie. VEB Gustov Fischer Verlag Jena.
16. Okur, N., 1997. Toprak Enzimleri Ders Notları. Ege Üniversitesi Ziraat Fakültesi Toprak Bölümü, Bornova, İzmir.
17. Pepper, I. L., Gerba, C.P., Brendecke, J.W., 1995. Environmental Microbiology: A laboratory anual. Academic Press, New York, pp. 175.
18. Rhoades, J. D. 1986. Cation Exchange Capacity, Chemical and Microbiological Properties. Methods of Soil Analysis, Part II. Madison: ASA and SSSA Agronomy Monograph, No: 9.

19. Rowell, M.J., Ladd, J.N., Paul, E.A. 1973. Enzymatically Active Complexes of Proteases and Humic and Analogues. Soil Biol. Biochem. (5): 699-703.
20. Schinner, F. 1986. "Veröffentlichungen der Landwirtschaftlich-Chemischen Bundesanstalt Linz / Donau". Seminar: Die Adwendung Enzymatischer und Mikrobiologischer Methoden in der Bodenanalyse.
21. Skujins J, 1973. Dehydrogenase: An indicator of biological activities in arid soil. Bulletin Ecological Communication (Stockholm) 17: 97-110.
22. Soil Survey Staff. 1992. Procedures for Collecting Soil Samples and Methods of Analysis for Soil Survey.
23. Soil Surv. Invest. Report, Washington D.C., USA: I. U.S. Gov. Print. Office.
24. Soil Survey Staff. 1993. Soil Survey Manual, USDA Handbook, Washington D.C., No: 18.
25. Soil Survey Staff, 2004. Soil Survey Laboratory Methods Manual Soil Survey Investigations Report, USDA, No:42.
26. Tabatabai, M.A., 1982. Soil Enzymes. In Methods of Analysis, Part 2, 2nd Ed. A. L. Page Et Al (Eds). Agronomy J. (9): 903-947.
27. Trevors, J.T., 1984. Rapid Gas Chromatographic Method to Measure H_2O_2 Oxidoreductase (Catalase)Activity in Soil, Soil Biology and Biochemistry, 16, 525-526.