ГЕОГРАФИЯ И ГЕНЕЗИС ПОЧВ

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THE EFFECTS OF TOPOSEQUENCES ON SOIL PROPERTIES AND UREASE ACTIVITIES

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Abstract The main objectives of this study were (i) to determine physico-chemical properties of six different soils (ii) to measure the range and degree of urease activities, (iii) to evaluate the influence of soil physico-chemical properties on urease activities in the both sides of the Çankırı-Acıçay River associated with specific landforms and different slope gradient. While right side soils of the Acıçay River are formed on quaternary alluvial deposits that find on terrace and floodplain, left side soils formed from quaternary alluvium, alluvial-collivial material and oligo-miocene gypsum and salt strata located on floodplain, terrace and steep lands respectively. Soil properties data of both sides of Acıçay River soils indicated significantly differences each other in terms of pedogenic processes which have been shaped by landscape position and parent material. According to soil taxonomy, 6 different soils were determined and classified as Entisol, Inceptisol and Mollisol along transect. In addition, it was found that changes of landscape positions associated with erosion and organic matter content can alter the soil urease activities within the soil profile and along different slope.

Key words: soil genesis, soil landscape, soil enzyme activity.

INTRODUCTION

The soil is an unconsolidated three-dimensional natural body that mantles the landscape. The characteristics and properties of soils are the result of a complex interaction of physical, chemical and biological reactions (soil forming reactions) [1]. Natural soil bodies are the result of climate and living organisms acting on parent material with topography and with time required for soil forming processes [2, 3]. These soil forming factors determine soil properties by governing the type and intensity of the pedological processes involved. Because the variable of climate, parent material, relief and time also govern geomorphic processes, landscape evaluation is intimately related to soil development [4]. Therefore, the characteristics of soils change from region to region or from place to place [5]. However, this changing is not coincidence in nature.

Several soil studies in arid and semi-arid areas indicate that soils show wide spatial variability resulting from differences in parent material, age of land surface, topography, water distribution, amount and intensity of rainfall and living organisms' heterogeneity [6, 7].

Soil is a complex system wherein chemical, physical and biochemical factors are held in dynamic equilibrium. Studies of enzyme activities provide information on the biochemical processes occurring in soil. There is growing evidence that soil biological parameters may be potential and sensitive indicators of soil ecological stress or restoration [8] and management-induced changes in soil quality [9]. Measurements of several enzymatic activities have been used to establish indices soil biological fertility [10]. The urease (UA) is involved in the hydrolysis of urea to carbondioxide and ammonia, which can be assimilated by microbes and plants. It acts on carbon-nitrogen (C-N) bonds other than the peptide linkage [11].

The study area has specific properties in terms of different topographical positions and parent material that influence distribution of plant patterns on both sides of Acıçay River. These cases are the main principal reasons for selection of this are. Therefore, the objectives of this study were (i) to determine physico-chemical properties of six different soils (ii) to measure the range and degree of urease activities, (iii) to evaluate the influence of soil properties on urease activities in the both sides of the Çankırı-Acıçay River associated with specific landforms and different slope gradient.

OBJECTS AND METHODS

The study area

The study was carried out transect along both sides of the Çankırı-Acıçay River which is a prominent land form, parent material and vegetation. The study area is located approximately between 557733E-4497924N, 557751E-4497889N and situated in vicinity of Çankırı province. It ranges in relief from 740 m to 800 m and four landscape positions (floodplain, terrace, backslope, shoulder), representing changes in geomorphology, topographic gradients and soil characteristics, were selected. The underlying bedrocks within the study area consist of primarily that while right side soils of the Acıçay River are formed on quaternary alluvial deposits that find on floodplain and terrace, left side soils are formed on quaternary alluvium, alluvial-collivial material spotted on floodplain and terrace oligomiocene gypsum and rock salt strata located on midslope and steep lands. Gypsum were commonly encountered with crystals, foliated (laminae) and mixing (not pure) forms. Vegetation cover varies through transect. Right side lands have been generally used for agriculture crops, while left side lands have covered three major plant community types (herb, shrub-grass, and grass) and upper lands is generally barren due to overgrazing. According to meteorological data, the mean annual temperature and rainfall are 11.1^{0}C and 417.7 mm. respectively. In addition, the study site has mesic soil temperature regime and xeric moisture regime [12].

Soil sampling

Based on the hypothesis that topography and parent material and also vegetation cover might be the main controlling factor in soil development. Soils have been studied on along transect (crosswise from East to West direction) with representative six profiles (Figure 1). Morphological properties of these six profiles in the field were identified and sampled by genetic horizons and classified according to Soil Survey Staff (1993 and 1999) [12, 13]. 25 soil samples were taken to investigate for their physical and chemical properties at the laboratory. Disturbed soil samples were then air-dried and passed through a 2 mm sieve to prepare for laboratory analysis.

Soil physico-chemical analysis

After soil samples were then air-dried and passed through a 2 mm sieve, particle size distribution was determined by the hydrometer method [14]. Coarse fragments from 2 to 60 mm were separated by passing from 2 mm sieve and mass coarse fraction ration (CFm) was calculated. Organic matter was determined in air-dry samples using the Walkley-Black wet digestion method [15]. pH, electrical conductivity (EC) were determined according to Soil Survey Laboratory [16]. Lime content by Scheibler calsimeter [13]. Total gypsum by precipitation with $BaCl_2$ [17]. Cation exchange capacities (CEC) was measured using a 1 N NH_4OAC (pH 7) method [16].

Urease activities

Urease (EC 3.5.1.5) activity (UA) was measured by the method of Hoffmann and Teicher [18]**.** 0.25 ml toluene, 0.75 ml citrate buffer (pH, 6.7) and 1 ml of 10 % urea substrate solution were added to the 1 g sample and the samples were incubated for 3 h at 37^{0}C. The formation of ammonium was determined spectrophotometrically at 578 nm and results were expressed as mg N g^{-1} dry sample.

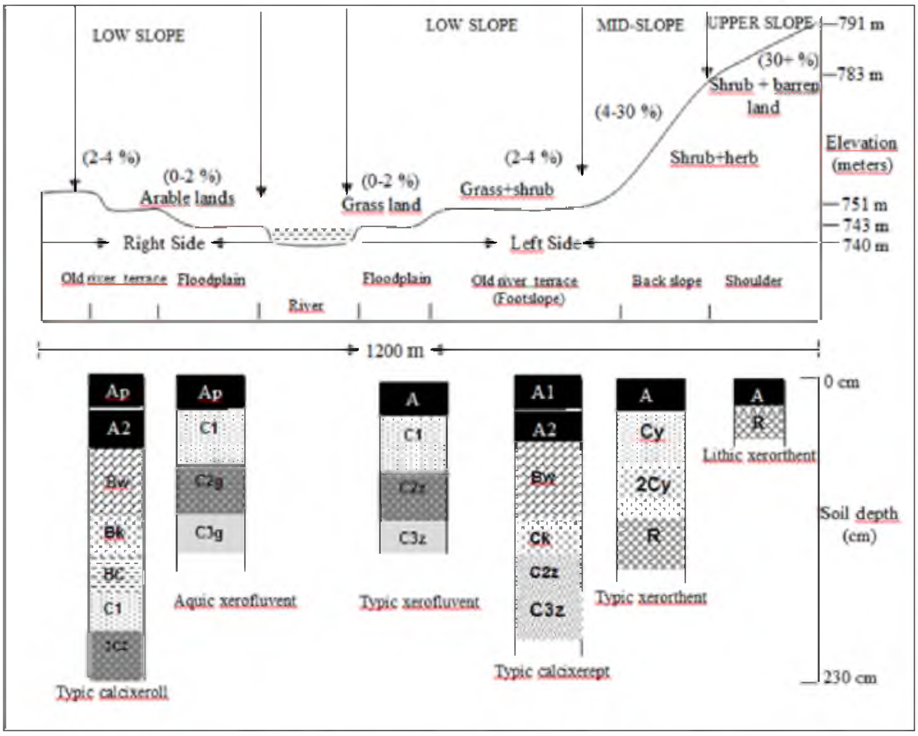

Figure 1 – Different soil formations on various parent materials, slopes and land covers along the transect of both sides of the Acıçay river

Statistical analysis

All results are reported as the mean value of three replicate determinations calculated on an oven-dry basis. Moisture was determined by weight loss after drying the soil at 105^{0}C for 48 h. Statistical analyses were performed by using the Statistical Package for Social Science (SPSS 10.0) program. The asterisks, * and ** indicate significance at P<0.05 and P<0.01, respectively.

RESULTS AND DISCUSSION

Physico-chemical properties of soil

Field physical characterization data for representative profiles of the soils are presented in Figure 1and Table 1. Soil physical properties that have been taken into consideration in this study showed variability as a result of dynamic interactions among natural environmental factors such as climate, parent material, land cover-land use and topography. Especially, slope has been regarded as one of the most important abiotic factors that control the pedogenic process on a local scale [19, 20]. Steeper slope contributes to greater runoff, as well as to greater translocation of surface materials down slope through surface erosion and movement of soil mass [21]. In left side soils, clay percentage of surface soils in low slope sides is more than on higher slope except floodplain top soil that is almost coarse recently alluvial deposits and the sand content for slopes with high gradient is higher than for low slopes. The same conclusion is supported by Rezaei and Gilkes [22] in a study in the Iran. A logical reason of this event is that in low slope (2-4 %) accumulation processes and in upper slope (> 30 %) runoff processes are dominant. This case is similar to the coarse fragment ratio (CFr). While the lowest value (0.44 %) of CFr is for slopes ranging from 0 to 2 %, the highest values of CFr that are steadily increased with increasing slope gradient are 34.52 %. While right side floodplain of Acıçay River finer- textured soils, sand and coarser textured soils occupied the opposite bank (Table 1).

Effect of topography on soil thickness has been reported by many researchers [22-25]. Soils along transect of left side of Acıçay River display variation in terms of participle distribution and depth in surface horizon. These variables are the obvious effect of eroding forces. Therefore, surface soils were carried and accumulated from uplands to low lands leading to progressively redder, deeper and finer texture soils with decreasing elevation. While the deepest soil formed on low slope class (2-4 %) or terraces, shallow soils cover on steep slope.

Table 1 – Selected physicochemical properties for the six typical soil profiles

Horizon	Depth, cm	Particle size				CFm >2 mm, %	pH	EC, dS m^{-1}	O.M, %	$CaCO_3$, %	Gypsum, %	CEC, cmol kg^{-1}
		C, %	Si, %	S, %	class							
Right side floodplain (PI) Aquic Xerofluvent												
Ap	0-14	31	44	25	CL	1.1	7.52	1.90	1.92	12.23	0.18	16.70
C1	14-40	18	46	35	L	23.1	7.53	1.13	0.78	11.53	0.21	15.43
2C2g	40-69	11	9	80	LS	64.6	7.66	1.80	0.33	7.78	0.21	10.75
2C3g	69+	15	24	61	SL	20.3	7.52	2.92	0.65	8.84	0.25	12.45
Right side old river terrace (PII) Typic Calsixerept												
Ap	0-22	41	37	22	C	1.41	7.28	1.79	2.44	10.61	0.10	15.61
A2	22-53	32	44	24	CL	1.05	7.52	1.70	1.21	12.37	0.13	15.74
Bw	53-113	38	38	24	CL	0.96	7.47	2.61	1.11	13.14	0.24	22.08
Bk	113-149	43	39	18	SiC	0.54	7.80	3.22	1.05	17.34	0.74	25.08
BC	149-185	36	49	15	SiCL	0.13	7.83	3.85	0.98	12.08	0.66	19.45
C1	185-229	48	37	15	C	0.21	7.78	4.50	0.72	11.64	0.50	22.74
C2	229+	45	43	12	C	0.74	7.48	2.80	0.70	12.14	0.34	18.70
Left side floodplain (PI) Typic Xerofluvent												
A	0-6	5	22	73	LS	0.44	7.53	3.50	0.98	15.73	0.53	9.04
C1	6-15	9	53	38	SiL	1.33	7.77	4.71	0.72	15.19	0.62	9.35
C2z	15-26	9	43	48	L	2.16	7.93	9.32	0.78	14.66	1.33	11.65
C3z	26+	8	39	54	SL	5.31	7.82	8.71	0.59	14.66	1.44	10.62
Right side old river terrace (PII) Typic Calsixeroll												
Ap	0-22	41	37	22	C	1.41	7.28	1.79	2.44	10.61	0.10	15.61
A2	22-53	32	44	24	CL	1.05	7.52	1.70	1.21	12.37	0.13	15.74
Bw	53-113	38	38	24	CL	0.96	7.47	2.61	1.11	13.14	0.24	22.08
Bk	113-149	43	39	18	SiC	0.54	7.80	3.22	1.05	17.34	0.74	25.08
BC	149-185	36	49	15	SiCL	0.13	7.83	3.85	0.98	12.08	0.66	19.45
C1	185-229	48	37	15	C	0.21	7.78	4.50	0.72	11.64	0.50	22.74
C2	229+	45	43	12	C	0.74	7.48	2.80	0.70	12.14	0.34	18.70
Left side back slope (PIII) Typic Xerorthent												
A	0-20	28	39	41	L	26.90	7.45	7.52	0.78	11.31	1.76	18.16
Cy	20-44	26	33	51	SCL	15.30	7.56	5.11	0.52	13.29	13.43	16.11
2Cy	44-120	23	42	36	L	10.25	7.75	16.62	0.33	10.61	21.71	16.30
R	120+	-	-	-	-	-	-	-	-	-	-	-
Left side shoulder (PIV) Lithic Xerorthent												
A	0-18	14	24	62	SL	34.52	7.42	9.79	0.46	6.36	20.13	18.09
R	18+	-	-	-	-	-	-	-	-	-	-	-

Topsoil textural classes that were affected by slope gradient have the following distribution with decreasing elevation: Coarse sandy loam, clay loam, clay. This result to some extent is concurrence with the result of Kreznor et al. [26]. Rezaei and Gilkes [22] in their study showed dependency of particle size on landscape attributes, including slope gradients. However there is an abrupt textural transition from old river terrace soils to floodplain soils that contain loamy sand texture. There are common pebbles and cobbles within profiles of floodplain of both sides. Phillips et al. [27] indicated that the soil on the terrace shows greater soil development and better drainage compared to the soil on the floodplain. The same results were also observed in the study area. This is because of the higher position of this soil on the landscape. Moreover, the effect of parent material on structure and solum depth of the left side soils is more than the effect of landscape position. Soil profile thickness and soil clay content are important parameters for water retention. Benny and Stephens [23] reported that soil profile thickness was considered an effective element in determining soil quality, especially considering storage of plant available water and nutrients. Rezaei and Gilkes [22] also indicate that this case is a very important soil physical property especially for rangelands, which usually receive no artificial fertilizer.

Soil chemical properties on different slope position and parent material were significantly affected by the degree of soil development and leaching processing. In addition, Gerrard [28] also indicated that the movement and distribution of water on slopes is one of the primary reasons for differences of soil properties on landscapes. Soil pH and EC are generally greater at depth than at the soil surface. This case was particularly observed in left side terrace soil that has significantly high pH values (7.80-8.75), whereas pH value of right side terrace soil varies between 7.28-7.83. It seems that this situation has significantly effect on distribution of land uses and plant pattern of both sides of Acıçay River.

Many studies have made correlations between soil properties and landscape positions-slope and parent material. In their study, Brubaker et al. [29] found 13 soil properties that differed with landscape position on four fields in eastern Nebraska. According to their results, sand, silt, pH, EC, calcium carbonate ($CaCO_3$) generally increased down slope. Clay content, OM and CEC generally decreased down slope. On the other hand, in this study it was found that clay content, OM, and CEC generally increased from upper slope to low slope lands. Soil organic matter content depends on the complex interaction of several factors including the quantity and quality of litter fall, climatic factor, soil properties (especially the amount and type of clay), and erosion [30]. Soils of the both sides of Acıçay River have consistently low organic matter ranging from 0.46 to 2.61 % (Table 3). For all soils, the organic matter is the highest in the surface horizon and decreases sharply to its lowest level in the subsoil. In the study area, the reasons of the low level organic matter are attributable to rapid decomposition and mineralization of organic matter (especially, due to intensive agricultural activities for right side), to overgrazing and to soil erosion (due to high slope for left side). Cation exchange capacity in the soils ranged from 9.04 to 27.18 cmol kg^{-1}. CEC values generally tended to be more related to the clay content (r = 0.901**), because organic matter content is generally low particularly in subsurface horizons. On the other hand, it was found statistically relation between organic matter and CEC (r = 0.596*). The gypsum content, which is relatively high in the fresh parent material (from 13.43 % to 21.71 %) is low relatively low from 0.10 % to 1.76 % in most surface horizons.

Soil urease activities

The urease activities are presented in Figures 2 for each landscape position and profiles. There were significant differences in extracellular urease enzyme activities among landscape positions and soil depth. Close observation suggests that there is a tendency for greater values in urease activities at the old river terrace for both sides of river. Moreover, urease activities on shoulder and backslope position in left side were significantly lower than the old river terrace in footslope position, which was agreement with Aşkın and Kızılkaya [31]. This situation may be based on erosion and soil organic carbon deposition in footslope position. Gregorich and Anderson [32] and Fu et. al. [33] reported that backslope and shoulder soils were the most affected by erosion and footslope soils showed the higher clay and organic matter content. Because of the high in organic matter contents, it was assumed that organic matter and clay content might be affecting the enzyme activities of soils. For all landscape positions, urease activities showed similar trend in all profiles. In all positions and each sides, urease activities in soils decreased from the surface soil downwards indicating that the major part of the location is existed to the A horizon. On the contrary, the minority of urease activities has generally remained in the C horizon of the all profiles. Additionally, urease enzymes exhibited similar pattern on all profiles (Figure 2).

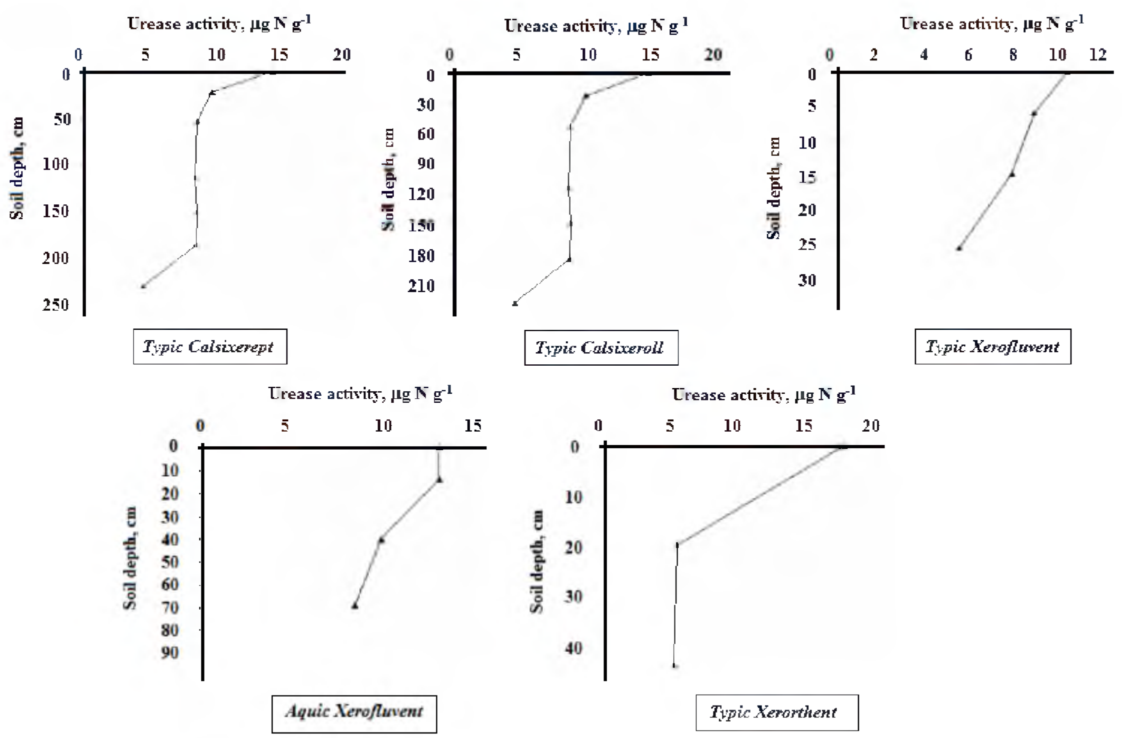

Figure 2 – Distribution of urease activity in soil profiles

The same results were found by Bergstrom et al [34]. They suggested that higher proportion of organic matter and enzyme activities such as urease, phosphatase, arylsulphatase, b-glucosidase and dehydrogenase in A horizon in a Grey Brown Luvisol (Hapludalf) at all landscape position. Shukla et al. [35] assumed that higher organic matter and urease activities higher 0-10 deep soil and decreased with soil depth. Enrichment of organic matter and urease activities in surface soil is also reported by Zaman et al., Speir and Ross [36, 37] suggested that the distribution of

APA and ASA correspond with the distribution of microorganisms in the profiles. The decrease in enzyme activities with depth can be mainly attributed to the diminution of biological activity down the profile. Inactivation of urease enzymes by clay minerals in the deeper horizons may be partly responsible for the different distribution patterns of the enzymes with depth [37].

The soil organic matter gave the significant correlations with extracellular urease activities (Figure 3), but not significantly correlated with the other soil physico-chemical properties. In both sites, the microbial community of the highly skeleton has consumed relatively more organic matter than the other soil physico-chemical properties. Similarly, other studies [38-40] showed that soil organic matter content was significantly correlated with the soil urease activities. The organic matter content, related with soil biological activities, is often used as an index of soil biological activity. Indeed, the microorganisms and their synthesized urease enzymes have been shown to be more sensitive than the total carbon concentration for soil management practices [41].

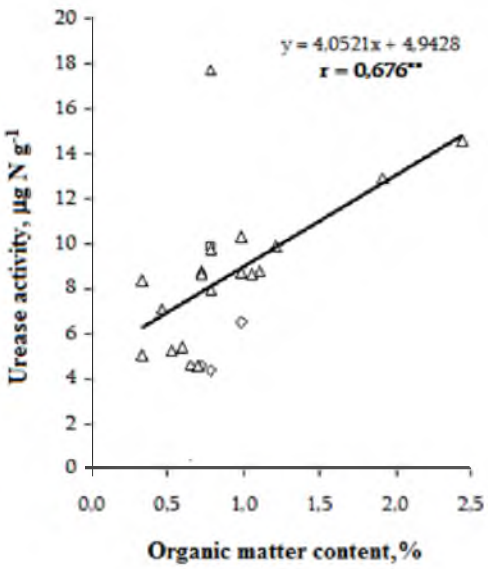

Figure 3 – The relationships between soil organic matter content and urease activities

CONCLUSION

Soil chemical and physical properties data of these both sides of Acıçay River soils indicated significantly differences each other in terms of pedogenic processes which have been shaped by landscape position and parent material. Another way to view this concept that these factors are keys on soil forming processes especially at the local region. In addition, the results also indicated the enzyme activities along a hillslope and soil profile had the great differences in the soils. The old river terrace in footslope position has greater organic matter contents compared the other positions, because the higher levels in the fine particles and organic matter content clearly show erosional depositing at the footslope and denudation of shoulder. The main effects of the organic matter on the urease activities may be welded the accumulation or decomposition of organic matter and erosion and deposition. The organic matter strongly correlated with urease activities suggests the number and activity of soil microorganisms depend on mainly of mineralizable substrate and urease enzyme synthesizing. In conclusion, this study demonstrated changes of landscape positions can alter the soil urease activities within the soil profile. Landscape position associated with erosion resulted in high variability of enzymes. It is, therefore, a special and interesting area for the performance of an integrated analysis of soil enzymes in relation to landscape position and soil profile.

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ТҮЙІН

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ТОПЫРАҚ ТОПОТҮСІРІЛІМНІҢ ТОПЫРАҚ ҚАСИЕТТЕРІНЕ ЖӘНЕ УРЕАЗА БЕЛСЕНДІЛІГІНЕ ӘСЕРІ

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Зерттеудің негізгі мақсаттары: (i) 6 түрлі топырақтың физикалық-химиялық қасиеттерін анықтау; (ii) уреазаның белсенділігінің мөлшерін және ауқымын өлшеу; (iii) арнайы рельефтермен, градиент бағытымен ерекшеленетін Чанкыры-Ачисай өзенінің екі жағындағы топырақтың құрамындағы уреаза белсенділігіне физикалық және химиялық қасиеттерінің әсерін бағалау. Ачисай өзенінің оң жақ беткейінің топырақтары терраста және су тасқынында орналасқан төртінші аллювиалды шөгінділерде қалыптасатын болса, сол жағынан беткі қабатта орналасқан топырақтар төртінші аллювиалды, аллювиальдық-колливалық материалдан және олигомиоцендік гипстен және тұз қабаттарынан тұрады, олар жазықтықта, терраста және тік жерлерде орналасқан.

Ачисай өзендерінің екі жағындағы топырақтарының қасиеттері туралы деректер ландшафтық жағдайға және бастапқы материалға сәйкес қалыптасқан топырақ процестеріне қатысты бір-бірінің арасында айтарлықтай айырмашылықтарды көрсетеді.

Топырақтың таксономиясына сәйкес, 6 түрлі топырақ анықталды және кескін бойынша Entisol, Inceptisol және Mollisol ретінде жіктелді. Бұдан басқа, эрозиямен және органикалық заттардың құрамымен байланысты ландшафт жағдайындағы өзгерістер топырақ профилінің ішіндегі және басқа беткей бойынша топырақтың уреазасының белсенділігіне әсер етуі мүмкін екендігі анықталды.

Түйінді сөздер: топырақ генезисі, топырақтың ландшафты, топырақ ферменттерінің белсенділігі.

Р

РЕЗЮМЕ

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ВЛИЯНИЕ ТОПОСЪЕМКИ НА ПОЧВЕННЫЕ СВОЙСТВА И ДЕЯТЕЛЬНОСТЬ АКТИВНОСТИ УРЕАЗЫ

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Основными задачами данного исследования были (i) определение физико-химических свойств шести различных почв (ii) измерение диапазона и степени активности уреазы, (iii) оценка влияния физико-химических свойств почвы на деятельность уреазы на обеих сторонах реки Чанкыры-Ачисай в зависимости от рельефа и градиента уклона. В то время как, почвы правобережья реки Ачиджай образованы на четвертичных аллювиальных отложениях, находящихся на террасе и пойме, почвы левобережья образованы из четвертичного аллювия, аллювиально-коллювиального материала и олигомиоценовых гипсовых и соляных пластов, расположенных в пойме, террасе и на крутых склонах. Данные о свойствах почв с обеих сторон реки Ачиджай свидетельствуют о значительных различиях их между собой в соответствии с почвенными процессами, в которых они были сформированы по их ландшафтному положению и исходному материалу. В соответствии с таксономией почв были определены 6 различных почв, которые были классифицированы как Entisol, Inceptisol и Mollisol вдоль разреза. Кроме того, было обнаружено, что изменения ландшафта, связанные с эрозией и содержанием органических веществ, могут влиять на деятельность почвенной уреазы как в пределах профиля почвы, так и вдоль различных склонов.

Ключевые слова: почвенный генезис, почвенный ландшафт, активность почвенных ферментов.