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# Soils of Amik Plain (Turkey): Properties and Classification

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**Abstract:** This study was aimed at determining chemical and physical properties and classifying soils of Amik Plain. The study revealed presence of 29 soil series in Amik Plain. Soils determined were classified as Entisol, Vertisol, Inceptisol, Alfisol and Mollisol according to Soil Taxonomy. Soil Organic Matter (SOM) for a depth of the upper two horizons ranged from 0.6 to 3.9% except for SOM-rich histic epipedon (20-22%). Bulk Density (BD) of the soils varied between 0.68-1.58 g $cm^{-3}$. High clay content of the soils ranging from 87.3 to 21.9% for the entire horizons causes poor drainage conditions in about 70% of the Amik Plain. Sustainability of prime farmlands of the Amik Plain can be ensured by best management practices such as no-till and/or reduced-till, residue conservation, windbreaks, rotational cultivation, ecologically suitable crop selection, integrated pest management and intercropping.

**Key words:** Soil classification, soil taxonomy, physical and chemical properties

## INTRODUCTION

Soils composed of mineral and organic materials and living forms in which plants grow are a dynamic natural body. The properties of soil vary spatially in a way not random. Formation of soils is a function of climate, vegetation, fauna, parent material, topography and time. During the formation of soils, the processes of additions, losses, translocation and transformations take place in the soils[1]. Information about soil properties and classification over tracts of land is vital for making decisions about uses and management of natural resources, environmental protection, land use planning and precision agriculture. This has been the basis for systematic soil surveys, soil survey interpretations and mapping of soil properties[2]. Soil surveys in developing countries have been the primary work to be undertaken for a number of projects related to agricultural production and land use[3]. Traditionally, soil maps were prepared to evaluate lands for different uses, but recently there has been an increasing emphasis on appraisals of crop suitability[4-6] and simulation models to estimate crop production[7,8]. For these models to be run, readily available datasets concerning climate, soil, vegetation and geomorphology are required[9].

The last 30-year advances in multivariate methods for classification, regionalized variable theory and computer tools such as Geographic Information Systems (GIS) have provided soil scientists with the means of better understanding and modeling of the complex distribution of soil over space and time[10]. Amik plain is one of the most productive agricultural lands in Turkey, with the most planted crops of cotton (*Gossypium hirsitum* L.) (70% of the cropland area in 2003), maize (*Zea mays* L.) and wheat (*Triticum aestivum* L.)[11]. There is no detailed inventory and survey of soils of the Amik Plain which provides the basis for sustainable management and land-use planning. The objective of this study was, therefore, to determine chemical and physical soil properties and soil-classification of the Amik Plain.

## MATERIALS AND METHODS

The study region is located in the province of Hatay (Turkey) (35° 47'-36° 24' E; 35° 48'-36° 37' N) and has a total area of *ca.* 75000 ha. The study region is delimited by Nur Mountain (1073 m) in the west, Syria and Reyhanli town in the east, Hassa and Kirikhan towns in the north, Ankatya city and Altinozu town in the south. The climate regime prevalent in the study area is Mediterranean climate characterized by a hot dry summer and a mild winter during which about 67% of the annual precipitation of 1,124 mm occurs. Average annual temperature reaches a maximum of 31°C in the summer and a minimum of -15°C in the winter, with an average annual temperature of 18°C. Parent materials of the study area consist mostly of alluviums and lacustrines. Lacustrines are relatively flat and often have parent materials with uniform properties. The alluvial soils formed by Orontes, Afrin and Karasu rivers are the most productive soils. Lake Amik of *ca.*

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53 km$^2$ in the north-west of the Amik Plain was drained into the Orontes River in order to increase the area of croplands[12].

Landsat 7 ETM image of 2001, aerial photographs of 1992 at 1:25.000 and photographic maps of 1:25.000 were used to prepare soil map of study region. Descriptions of soil series in the Amik Plain were accomplished according to soil survey manual during a two-year period (2003 and 2004)[13]. Soil samples collected from all horizons were analysed for total soluble salts[14], CEC (Cation Exchange Capacity)[14], texture[15], pH[16], organic matter[17], $CaCO_3$[18] and bulk density[19]. Soil classification was accomplished using Soil Taxonomy[20] and FAO/UNESCO[21].

## RESULTS

**Physical and chemical characteristics:** We have identified 29 soil series and 11 soil suborders. In this study, results of soil series most typical of each of the soil suborders are presented here due to the limited space. The horizon orders of the profiles in study area were defined to be A-C form except for Acarköy with a Cambic B horizon. This means that almost all the soils in the study area are young soils. There are not significant differences in the values of pH. All series had a slightly alkaline reaction ranging from pH 7.2 to 8.2 and a very high base saturation (Table 1).

Although salic horizon did not exist in soils of the study area, the soil series of Apaydin, Akkuyu, Karacanlik, Kangallar, Comba and Karabatak had slightly soluble salt content and Suluköy had moderately soluble salt content. Soil CEC varied between 23 to 68 me/100 g (Table 1). The soil with the highest CEC was Comba with a Histic horizon, while the lowest value was determined in Kangallar. Except for Paşaköy, all the series had high $CaCO_3$ ranging from 22.5 to 58.7%. Kangallar, Karacanlik, Bağlama, Comba and Acarköy series had a Calcic horizon.

The soils of the Amik Plain were determined to be poor in Soil Organic Matter (SOM) for the first two horizons ranging from 24 to 59 cm in depth. Soil organic matter ranged from 0.6 to 3.9% except for SOM-rich histic epipedon of Comba soil series. Comba classified as Histic Humaquept had 20-22% SOM content. Soil organic matter contents decreased with depth in all the soil series. Bulk Density (BD) of the soils varied between 0.68-1.58 g cm$^{-3}$. Bulk density values of the Comba with Histic epipedon was relatively low (0.68-0.78%). Soil texture of Akkuyu, Karacanlik, Acarköy, Suluköy and Karabatak series was clayey in throughout the profiles. The lowest sand content was found in Acarköy. Among all the horizons, the maximum clay content (87.3%) throughout the soils of the plain was determined in Suluköy, while the lowest content (21.9%) was determined in Kangallar. Furthermore Acarköy, Suluköy and Karabatak had an Argillic horizon with high clay accumulation.

**Soil classification:** The soils were classified according to the criteria proposed by the Soil Taxonomy[20] and FAO/UNESCO[21] based on morphological, physical and chemical characteristics. According to the meteorological data, the study region has xeric soil moisture regime and thermic soil temperature regime. Soils of the Amik Plain were classified as Entisols, Vertisols, Inceptisols, Alfisols and Mollisols and as Fluvisols, Vertisols, Calcisols, Phaeozems ans Luvisols according to Soil Taxonomy[20] and FAO/UNESCO[21], respectively (Table 2). The majority of the soils were Entisol and Inceptisol since they were developed on young fluvial and lacustrine deposits.

## DISCUSSION

Since the Amik plain has been developed on young parent materials, its soils do not have pronounced diagnostic subsurface horizons except for a few Argillic and Cambic horizons. Because of the heavy clay texture, soils of the Amik plain pose some difficulties for agricultural activities such as cultivation, irrigation and drainage. The majority of the Amik Plain soils have high $CaCO_3$ as parent materials of these soils have very high $CaCO_3$. Bulk density of the surface horizons was lower than that of the subsurface. Moreover, some horizons designated as “Ad” have been exposed to soil compaction by agricultural machinery. Organic soils left behind after the drainage of the Lake Amik have been cultivated for 40 years which decreased SOM considerably. There are still soils rich in SOM content (20-22%) in the some parts of the study area such as Comba.

Sustainability of prime farmlands of the Amik Plain is threatened by mismanagement practices and ecologically incompatible land uses. For example, salinization is emerging increasingly as a major problem in the soils of the Amik Plain due to poor drainage conditions caused by heavy soil texture in about 70% of the soils, use of salty irrigation water drawn from drainage channels and lack of efficient and effective drip irrigation systems[22]. In parallel to the rapid increase in population of Antakya for the last 30 years, there has been an urban sprawl towards prime farmlands of the Amik plain[23]. The expansion of urbanization and agricultural areas causes the irreversible losses of prime farmlands and natural habitats whose goods and services are indispensable for the well-being of local communities and ecosystems, such as drainage of the Lake Amik and its neighboring wetlands of about

Table 1: Results of physical and chemical analyses of soil series of Amik Plain

| Soil series | Horizon | Depth (cm) | pH | Total salt (%) | CEC me/ 100 g | $CaCO_3$ (%) | SOM (%) | BD g/cm$^3$ | Texture (%) | | | Texture class |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | Sand | Silt | Clay | |
| Apaydin | | | | | | | | | | | | |
| (Vertic | Ap | 0-30 | 7.6 | 0.090 | 38.7 | 42.5 | 1.35 | 1.19 | 9.3 | 30.0 | 60.7 | C |
| Xerofluvent) | A2 | 30-53 | 7.8 | 0.095 | 39.1 | 42.0 | 1.02 | 1.22 | 9.7 | 32.7 | 57.6 | C |
| | C1 | 53-125 | 7.8 | 0.260 | 28.5 | 45.7 | 0.73 | - | 7.6 | 43.7 | 48.7 | SiC |
| | C2ss | 125-140 | 8.0 | 0.190 | 36.9 | 41.7 | 0.28 | - | 7.6 | 49.9 | 42.5 | SiC |
| Günova | | | | | | | | | | | | |
| (Typic | Ap | 0-31 | 8.1 | 0.075 | 40.6 | 27.1 | 2.13 | 1.28 | 10.2 | 23.5 | 66.3 | C |
| Xerofluvent) | C | 31-46 | 8.1 | 0.092 | 37.3 | 34.3 | 0.61 | 1.29 | 9.0 | 28.2 | 62.8 | C |
| | 2A | 46-67 | 8.1 | 0.090 | 36.7 | 28.1 | 0.97 | - | 25.6 | 25.9 | 48.5 | C |
| | 2CA | 67-83 | 8.1 | 0.110 | 31.3 | 32.8 | 0.86 | - | 29.2 | 26.4 | 44.4 | C |
| | 2C | 83-120 | 8.0 | 0.152 | 27.5 | 36.4 | 0.27 | - | 32.3 | 29.4 | 38.3 | CL |
| Akkuyu | | | | | | | | | | | | |
| (Chromic | Ap | 0-17 | 7.9 | 0.089 | 43.4 | 24.4 | 1.12 | 1.14 | 6.0 | 17.6 | 76.4 | C |
| Haploxerert) | Ad | 17-33 | 7.9 | 0.102 | 42.7 | 24.4 | 1.24 | 1.49 | 6.2 | 17.3 | 76.5 | C |
| | A3ss | 33-70 | 8.1 | 0.124 | 47.3 | 22.8 | 1.05 | - | 6.5 | 15.4 | 78.1 | C |
| | ACss | 70-98 | 8.0 | 0.191 | 48.5 | 23.6 | 0.88 | - | 4.5 | 15.4 | 80.1 | C |
| | Css | 98-130 | 8.0 | 0.357 | 43.1 | 26.0 | 0.55 | - | 6.1 | 31.2 | 62.7 | C |
| Karacanlik | | | | | | | | | | | | |
| (Chromic | Ap | 0-10 | 8.0 | 0.068 | 29.5 | 46.2 | 1.70 | 1.41 | 74 | 20.3 | 72.3 | C |
| Calcixerert) | Ad | 10-24 | 8.0 | 0.082 | 30.7 | 47.2 | 1.60 | 1.43 | 9.3 | 26.1 | 64.6 | C |
| | A3ss | 24-38 | 8.2 | 0.095 | 35.3 | 35.0 | 0.56 | - | 8.2 | 22.6 | 69.2 | C |
| | C1ss | 38-64 | 8.1 | 0.088 | 40.0 | 38.2 | 0.65 | - | 6.2 | 18.6 | 75.2 | C |
| | C2ss | 64-86 | 8.0 | 0.240 | 40.9 | 27.1 | 0.63 | - | 5.1 | 9.2 | 85.7 | C |
| | C3ss | 86-120 | 8.0 | 0.254 | 36.0 | 29.4 | 0.64 | - | 5.4 | 18.1 | 76.5 | C |
| Kangallar | | | | | | | | | | | | |
| (Typic | Ap | 0-15 | 7.8 | 0.065 | 34.7 | 26.7 | 1.82 | 1.25 | 19.6 | 30.5 | 49.9 | C |
| Calcixerept) | A2 | 15-31 | 7.9 | 0.080 | 36.7 | 26.8 | 1.68 | 1.46 | 17.3 | 47.9 | 34.8 | SiCL |
| | C1 | 31-62 | 7.7 | 0.210 | 25.0 | 39.2 | 0.33 | - | 19.3 | 48.7 | 32.0 | SiCL |
| | C2 | 62-104 | 7.0 | 0.180 | 25.4 | 40.1 | 0.14 | - | 15.3 | 58.5 | 26.2 | SiL |
| | C3 | 104-120 | 7.9 | 0.330 | 23.8 | 36.2 | 0.10 | - | 37.6 | 40.5 | 21.9 | L |
| Bağlama | | | | | | | | | | | | |
| (Vertic | Ap | 0-21 | 7.7 | 0.089 | 35.1 | 18.8 | 1.69 | 1.54 | 11.2 | 40.8 | 40.8 | SiC |
| Calcixerept) | A2 | 21-59 | 8.0 | 0.052 | 37.2 | 18.8 | 1.19 | 1.58 | 13.5 | 35.2 | 51.3 | C |
| | AC | 59-80 | 8.0 | 0.046 | 32.8 | 22.5 | 0.91 | - | 16.7 | 39.4 | 43.9 | C |
| | C | 80-120 | 8.1 | 0.044 | 30.5 | 25.6 | 0.67 | - | 23.6 | 39.2 | 37.2 | CL |
| Comba | | | | | | | | | | | | |
| (Histic | Ap | 0-21 | 7.2 | 0.210 | 63.9 | 29.7 | 20.14 | 0.78 | 37.2 | 35.8 | 27.0 | CL |
| Humaquept) | A2 | 21-38 | 7.2 | 0.219 | 68.4 | 27.1 | 22.04 | 0.68 | 39.7 | 33.5 | 26.8 | L |
| | C | 38-55 | 7.5 | 0.205 | 23.6 | 58.7 | 6.26 | - | 29.4 | 34.8 | 35.8 | CL |
| | 2A | 55-65 | 7.4 | 0.200 | 35.1 | 47.2 | 6.86 | - | 21.8 | 35.5 | 42.7 | C |
| | 2Ck | 65-98 | 7.7 | 0.225 | 27.8 | 45.3 | 0.61 | - | 5.3 | 42.4 | 52.3 | SiC |
| | 2Ck2 | 98-120 | 7.9 | 0.258 | 41.9 | 43.1 | 0.60 | - | 5.8 | 13.3 | 80.9 | C |
| Acarköy | | | | | | | | | | | | |
| (Calcic | Ap | 0-30 | 7.8 | 0.089 | 45.3 | 23.3 | 1.76 | 1.24 | 5.6 | 24.3 | 70.1 | C |
| Haploxeralf) | A2 | 30-48 | 8.1 | 0.056 | 35.6 | 28.5 | 0.81 | 1.26 | 7.1 | 35.2 | 57.7 | C |
| | Bw | 48-101 | 7.9 | 0.061 | 44.2 | 24.1 | 0.74 | - | 4.9 | 20.6 | 74.5 | C |
| | C | 101-120 | 8.0 | 0.067 | 42.5 | 29.2 | 0.58 | - | 3.5 | 19.4 | 77.1 | C |
| Suluköy | | | | | | | | | | | | |
| (Vertic | Ap | 0-32 | 7.8 | 0.103 | 39.2 | 35.7 | 2.87 | 1.20 | 5.1 | 21.1 | 73.8 | C |
| Haploxeralf) | A2 | 32-51 | 7.8 | 0.209 | 40.1 | 31.7 | 3.91 | 1.25 | 9.5 | 19.3 | 71.2 | C |
| | 2A | 51-70 | 7.9 | 0.385 | 41.8 | 24.7 | 3.12 | - | 19.2 | 9.4 | 71.4 | C |
| | 2C1 | 70-90 | 8.2 | 0.445 | 33.9 | 26.9 | 1.09 | - | 6.4 | 6.3 | 87.3 | C |
| | 2C2ss | 90-130 | 8.3 | 0.515 | 40.2 | 27.1 | 0.55 | - | 8.2 | 6.3 | 85.5 | C |
| Karabatak | | | | | | | | | | | | |
| (Typic | Ap | 0-29 | 7.8 | 0.205 | 40.6 | 27.5 | 1.62 | 1.26 | 5.3 | 19.6 | 75.1 | C |
| Haploxeralf) | A2 | 29-47 | 7.9 | 0.155 | 39.4 | 29.4 | 0.84 | 1.38 | 4.9 | 25.1 | 70.0 | C |
| | CA | 47-70 | 7.9 | 0.139 | 27.7 | 52.9 | 0.84 | - | 5.7 | 15.2 | 79.1 | C |
| | C | 70-120 | 7.9 | 0.135 | 27.4 | 47.4 | 0.59 | - | 7.4 | 28.3 | 64.3 | C |
| Paşaköy | | | | | | | | | | | | |
| (Fluventic | Ap | 0-21 | 7.8 | 0.038 | 34.0 | 5.2 | 1.58 | 1.44 | 38.6 | 38.4 | 23.0 | L |
| Haploxeroll) | A2 | 21-37 | 7.7 | 0.040 | 34.9 | 4.7 | 1.67 | 1.45 | 36.7 | 35.9 | 27.4 | CL |
| | 2A | 37-54 | 7.6 | 0.037 | 32.9 | 1.9 | 1.65 | - | 45.1 | 28.0 | 26.9 | SCL |
| | 2CA | 54-72 | 7.9 | 0.035 | 30.0 | 8.3 | 0.94 | - | 42.8 | 34.7 | 22.5 | L |
| | 2C | 72-120 | 8.0 | 0.041 | 37.3 | 10.4 | 0.64 | - | 34.2 | 39.0 | 26.8 | L |

Table 2: Classifications of Soils of Amik Plain according to Soil Taxonomy[20] and FAO/UNESCO[21]

| Orders | Suborders | Great Groups | Subgroups | Soil Series | FAO/UNESCO |
|---|---|---|---|---|---|
| Entisol | Fluvent | Xerofluvent | Vertic Xerofluvent | Apaydin | Calcaric Fluvisol |
| | | | Typic Xerofluvent | Günova | |
| Vertisol | Xerert | Haploxerert | Chromic Haploxerert | Akkuyu | Eutric Vertisol |
| | | Calcixerert | Chromic Calcixerert | Karacanlik | |
| Inceptisol | Xerepts | Calcixerept | Typic Calcixerept | Kangallar | Haplic Calcisol |
| | | | Vertic Calcixerept | Bağlama | |
| | Aquept | Humaquept | Histic Humaquept | Comba | Haplic Phaeozem |
| Alfisol | Xeralf | Haploxeralf | Calcic Haploxeralf | Acarköy | Calcic Luvisol |
| | | | Vertic Haploxeralf | Suluköy | Vertic Luvisol |
| | | | Typic Haploxeralf | Karabatak | Chromic Luvisol |
| Mollisol | Xeroll | Haploxeroll | Fluventic Haploxeroll | Paşaköy | Haplic Phaeozem |

53 $km^2$[24]. In addition, the loss of SOM due to burning of crop residues, soil erosion and no or little application of manures results in soil compaction and hampers the nutrient cycling. Monoculture cultivation of cotton on vast areas of the Amik Plain has given rise to the intensification of such plant diseases as Verticillium and Fusarium caused by increased inoculum density of soil-borne pathogens[25].

Best management practices including no-till and/or reduced-till, residue conservation, windbreaks, rotational cultivation, ecologically suitable crop selection, integrated pest management and intercropping can increase levels of both agricultural productivity and environmental quality significantly[26]. Pursuit of ecological suitability analysis, sustainable land-use planning, adaptive environmental management and integrated policy strategies is most likely to secure the continued productivity of the Amik plain for present and future generations.

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