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Physical and chemical degradation of grassland soils in semi-arid regions: A case from Central Anatolia, Turkey

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ABSTRACT

The aim of this study is to determine some hydro-physical and chemical characteristics of soils on the grassland areas under semi-arid conditions in terms of soil degradation processes. Three sampling plots of 20 × 20 m size were selected from the Emen Plain as Locations-I, II and III basing on the area covered with vegetation and visual soil properties; and total 108 soil samples from 2 points and 3 depth levels (0–20 cm, 20–40 cm, 40–60 cm) of each sampling plot. Soils of the research area are in degradation process in terms of some physical and chemical characteristics. It was observed that soil properties (i.e. bulk density, total porosity, organic matter, pH, electrical conductivity and saturated hydraulic conductivity) in Location-II and Location-III changed negatively in comparison to Location-I almost at all depths. In the Location-III grassland, bulk density, pH, electrical conductivity and Na + values are higher than those in Location-I, whereas the organic matter, total porosity and saturated hydraulic conductivity values are low. Grassland area is vulnerable to erosion. High Exchangeable Sodium Percentage (ESP) values in Locations-II and III indicates the sodicity problem in these areas.

1. Introduction

The soil and water resources in the arid and semi-arid regions are being rapidly degraded (Zdruli, 2014; Prosdocimi et al., 2016). Natural factors that cause degradation problems mainly based on climate, hydrology, topography, geology, vegetation; on the other hand anthropogenic factors are related to land use/cover changes (Muñoz-Rojas et al., 2015), overgrazing (Ibañez et al., 2014), logistic services and waste material assessment (Öztaş, 1997). Degradation changes the soil chemical and biological environment through acidification, salinization, contamination (Krasilnikov et al., 2016), degradation of the soil structure (Baumgartl and Horn, 1991), organic matter loss (García-Orenes et al., 2005), compaction and etc. Especially, changes in soil organic carbon stock influences greenhouse gas concentrations (Parras-Alcántara et al., 2015). The importance of soil degradation is enhanced because of its impact on food security and environmental quality (Eswaran et al., 2001). Because of this reason many scientists of the world pay attention to studies about to control soil degradation by mulching (Prosdocimi et al., 2016), vegetation management, to improve soil organic carbon budget (Hueso-González et al., 2014; Parras-Alcántara et al., 2015), engineering techniques to management saline (Devkota et al., 2015) and acidic soils.

Degradation of soil by salts is one of the key threats to sustainability of crop and cattle production in most of the world's arid and semi-arid regions (Bossio et al., 2007). Taking into account that agriculture and grasslands are limited worldwide and the need for food increases incrementally. Reclamation and economic assessment of saline soils are extremely important issues (Woods, 1996). Therefore, it is utterly important to set forth the salinity, alkalinity and desertification problems on arid and semi-arid lands completely, and to try to understand the physical and chemical soil degradation processes on such lands. In this respect, specifying the reasons of degradations on these lands and identifying the degradation on soil properties will set light to conduct land management plans and set forth the implementations about the rehabilitation and remediation of the land. It will also make important economic contributions for the locals through reintegrating this land into agriculture and stockbreeding.

As in many semi-arid countries, some parts of Turkey also exposure from such problems as salinity, sodicity, soil degradation,

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etc. due to extreme ecological conditions. Soil degradation in arid and semi-arid regions, specifying the reasons of the degradations and rehabilitation of degraded areas are the issues that attract the attention. More than 1.5 million hectare areas in Turkey suffer from sodicity problem and 2.8 million hectare areas from drainage problem. 74.0% percent of the problematic lands consist of saline, 25.5% consist of saline-sodic and 0.5% consists of sodic soils (Sönmez, 2004; Kanber et al., 1992). Lands affected by saline in Turkey are: Konya-Ereğli, Aksaray, Malya Plains, Alluvial Down Seyhan Plain, Iğdır, Menemen, Bafra, Söke, Acıpayam and Salihli plains (Sönmez, 2004). The research area is within the boundaries of Konya Closed basin, which is one of the most important semi-arid lands of Turkey and affected by the potential negative effects of climate change. The research area has a bottom land structure together with a wide range of agriculture and stockbreeding potential. When it is considered that the means of living in the region are mainly depended upon agriculture and stockbreeding, it is foreseen that together with the effects of aridity and climate change, lands suffering from salinity and alkalinity will be increasing more in the future and soil degradation is an important threat to food security and other ecosystem services and environmental quality in this region. Degradation of soil by salts is one of the key threats to sustainability of crop production in most of the world's arid and semi-arid regions (Bossio et al., 2007). In these regions, low rainfall and high potential evapotranspiration contribute to the upward movement of salts in the soil solution, and affect physical, chemical and biological properties of soil negatively (Rengasamy, 2006). Taking into account that agriculture and grasslands are limited worldwide and the need for food increases incrementally, it appears that at least the present lands should be used more effectively. Therefore, reclamation and economic assessment of saline soils are extremely important issues (Woods, 1996). Accordingly, limited agriculture and grasslands available should be used more effectively, and recovery measurements should be taken for problematic lands to use them effectively. Therefore, it is utterly important to set forth the salinity, alkalinity and desertification problems on arid and semi-arid lands completely, and to understand the physical and chemical soil degradation processes on such lands. Physical, chemical and biological properties of soils represent the quality and productivity parameters of soils. Identifying the degradation process and specifying the reasons of degradation in such soil characteristics will undertake an instructive role in terms of finding how to utilize the soils in semi-arid regions. In order to utilize from soil in a true and sustainable manner, quality properties of the soils and the interaction between such properties should be known well. In this respect, specifying the reasons of degradations on these lands and identifying the degradation on soil properties will set light to conduct land management plans and set forth the implementations about the rehabilitation and remediation of the land. It will also make important economic contributions for the locals through reintegrating this land into agriculture and stockbreeding. So, soil degradation processes must be evaluated for sustainability of the grassland soils in this region.

The hypothesis in our study states that the soils in the semi-arid Emen Plain have exposed to physical and chemical degradation processes. Most probably, the soil alkalinity may have an impact on the degradation of soil properties.

2. Material and methods

2.1. Site description

This study was conducted in the Emen Plain within the borders of Niğde city located in Central Anatolia, Turkey. The study area is located between 37°48′10″-37°49′57″ north latitudes and 34°25′34″-34°27″04″ east longitudes (Fig. 1). Mean altitude of the research area is about 1200 m asl (above sea level). Average annual rainfall is 330.7 mm. Climate type is D,B′1,d,b'2 according to Thornthwaite method which means it is semi-arid, mesothermal, having no or a little excess water (Turkish Meteorological Turkish State Meteorological Service, 2014). Average annual temperature is 11.07 °C. Common land use practices are grassland, agriculture and residential areas. Economy of the research area depends upon agriculture and stockbreeding. Agriculture is generally applied through conventional methods, and apple growing applications by using advanced agricultural techniques have been observed in recent years. Mainly wheat, barley, sugar beet, clovers and feed crops such as common fodders are planted as agricultural products. However, a great part of this region is in the form of highly degraded non-productive grassland. Sheep and goat farming is carried out intensively. In recent years, some facility activities have been launched for the integrated stockbreeding implementations on the region, through remediation applications of the soil characteristics. The 18.6% of fields in the region have drainage problem. Furthermore, salinity and salinity + sodicity problems are observed in 90% of such fields. 79% of the salinity and sodicity problems are observed in grasslands. The soils of research area are alluvial, insufficiently drained and saline. The soils in the research area are alkaline and fine textured in general (Anonymous, 1993). General properties of research area soils are stated in Table 1.

Geological units that surrounding the study area are mainly represented by metamorphic, magmatic of the study region are represented by Paleozoic-Mesozoic metamorphic and sedimentary rocks and Cenozoic magmatic and sedimentary rocks (Fig. 2; MTA, 2002). However, the Emen Plain is located on the Quaternary alluviums of the Ereğli-Bor Basin. Groundwater in the study area flows westward, reaches the surface and constantly evaporates where the water table is close to the surface. The salt concentrations on plain floor are related to the capillary rise of the groundwater due to impermeable clay layer in the base of the aquifer. Also, there is no surface flow in the Emen Plain. The salt concentrated areas were observed extensively on Badak and Yeniköy neighbourhoods close to Emen region where detailed examinations were conducted. These areas cover a wide area on the middle and west parts of the basin as well. The researches carried out by using resistivity techniques on the basin indicate that such saline zones varied from 100 to 200 m as of the surface (Anonymous, 1972).

In order to achieve the aim of this research, three different sampling areas (Location-I, Location-II and Location-III) were specified by taking the land surveys conducted as well as measuring percentage of vegetation cover, plant height and visual differences (cracks, soil incrustation, salt particles, humidity, etc) on the soil surface into consideration. The land is used as grassland in all 3 sampling areas. Percentage of the vegetation covers in Location-I is 85%, 41% in Location-II and 9% in Location-III (Fig. 1). Plant species such as *Poa* sp, *Thymus* sp., *Avena* sp. and *Hordeum* sp. are present in the Location-I and the average plant height is 17 cm. The grasslands in Location-I seem more productive than the others. No soil crusts and saline particles were observed. Because of these properties this site evaluated as control site. On the Location-II, plant species such as *Thymus* sp., *Hordeum* sp., *Poa* sp. and *Bellis* sp. are also common, and the average plant height is 5 cm. In the profile, a hard soil layer was defined in 40 cm. Low amount of salt particles was observed. On Location-III, vegetation cover is very rare and there are *Thymus* sp. and *Poa* sp.; area seems non-productive. The average plant height is 2 cm. Humidity is high in the profile. Soil incrustation and low salt particles were observed on soil surface. Cattle grazing activities are conducted on the area.