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Changes on Soil Properties Associated with Soil Depth in Eroded Areas: A Case Study of Pamukcular Watershed

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Abstract:

This study was carried out to investigate changes on soil properties associated with soil depth in eroded areas under semi-arid climate conditions. Pamukcular Watershed (Yusufeli-Artvin-Turkey), with total annual rain amount of 250-400 mm and alluvial soils formed especially by sudden floods, was chosen as the study area. Due to poor vegetation cover, continuous surface erosion was observed for most of the year in the research area, leading us to predict that negative changes may have occurred in soil physical and chemical properties. In order to determine these changes, disturbed and undisturbed soil samples were taken at two depths (0-10 ve 10-20 cm) in 12 parcels with about 3% slope. When soil samples were taken, it was observed that vegetation cover rate was low (20%-30%). The results show that clay content, moisture, aggregate stability, pH, bulk density and dispersion rate of soils was significantly different between soil depths. However, silt, sand, lime and organic matter contents along with air and hydraulic conductivity did not show significant differences.

Key Terms: erosion, soil properties, Pamukçular

Introduction:

Soil erosion is well considered as a main threat to the efficient and sustainable use of soil and in some countries, it is known as a major environmental problem causing land degradation, decreasing chemical and physical soil fertility, lowering plant production and polluting water systems with organic or inorganic sediments (Lal, 1988; Nizeyimana and Olson, 1988; Kaihura et al., 1999; Rhoton et al., 2002). Globally, highly degraded land area has risen from 15% to 25% between 1991 and 2011, mostly due to soil erosion (UNCCD, 2013).

Soil erosion is specifically a serious problem in arid and semi-arid lands. Very low precipitation and consequently weak vegetation cover lead soils to be easily removed by runoff or wind in such areas. According to the Food and Agricultural Organization, estimated 24 billion tons of fertile soils have been lost only from the croplands of the World in the last century (FAO 2011). It is a fact that the top part (O and/or A horizon) of soils are the most affected from erosion processes, causing surface soil become shallower and less fertile (Ebeid et al. 1995).

Approximately %35 of Turkey's whole area is also classified as semi-arid and arid lands, making the country as very sensitive to soil erosion and land degradation (Türkeş, 2010). One of those semi-arid regions being affected by water and wind erosion lies within the Pamukcular Watershed in the northeast part of Turkey. As in all similar lands in Turkey, a general method preferred for mitigating these sites is usually planting seedlings of few species (e.g. *Robinia pseudoacacia* L.) to stop soil erosion. However, there is a lack of data on such areas in respect to physical and chemical soil properties, status of vegetation cover, climatic features and methods to protect them from erosion to stop degradation process. In this study, the main objective was to investigate selected surface and subsurface soil properties of this seriously eroded area to help in plantation and other soil protection efforts.

Materials and Methods:

The experimental site was located on Pamukcular Walley near Yusufeli, in Artvin (Figure 1). It was near another study area where the effect of planting caper (*Capparis ovata* Desf.) and sainfoin (*Onobrychis viciifolia* Scop) on soil protection characteristics, a research supported by TUBITAK, was investigated (Yuksek, 2009).

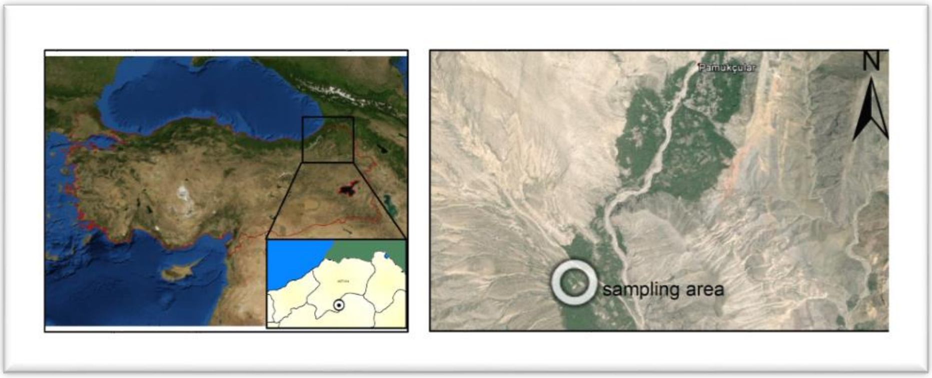

Figure 1. Study area showing sampling locations within the Pamukcular Watershed

Disturbed and undisturbed soil samples, totaling 24, were collected both from the surface (0-10cm) and subsurface layers (10-20cm) to be analyzed for texture, organic matter, bulk density, moisture content at field capacity, aggregate stability, pH, bulk density, hydraulic and air conductivity, loam content, and dispersion ratio.

Soil pH was measured in 1:2,5 soil:water suspension with a pH meter while organic matter (OM) was determined by the method of wet combustion (Nelson and Sommers, 1982). Particle size distribution was done using the hydrometer method (Gee and Bauder, 1986). While the core method was used for soil bulk density (Blake and Hartge, 1986), soil moisture content was determined based on weight by oven drying. Aggregate stability was measured on the 2 mm fraction of air-dry samples using wet sieving technique (Kemper ve Rosenau, 1986). Calcium carbonate (lime) content was determined by Scheiber's calcimeter in volumes (Nelson 1982) Electrical conductivity was determined by electrical conductivity equipment (Rhoades, 1982). Dispersion rates were calculated using the structural stability indexes (Lal, 1988). Air permeability and water permeability were determined by Kmoch device with 1-2mm aggregate (Corey, 1986) and by "constant water level permeameter (Klute and Dirksen, 1986), respectively.

Results and Discussion

Soil Texture (Sand, Silt and Clay Content)

Texture analyzing showed that the clay content was higher at the lower depth (Figure 2a) while both the sand and silt contents were higher at the surface (Figures 2b, c)). However, none of these results were statistically significant. These outcomes may be related to the young alluvial and colluvium materials of the study site, in which typical soil horizons have not yet been formed. Clay content being high at the subsurface can indicate the fact of washing down of clay to lower horizons by rain. High sand content at top of the study area can be considered another indication of severe erosion in the site.

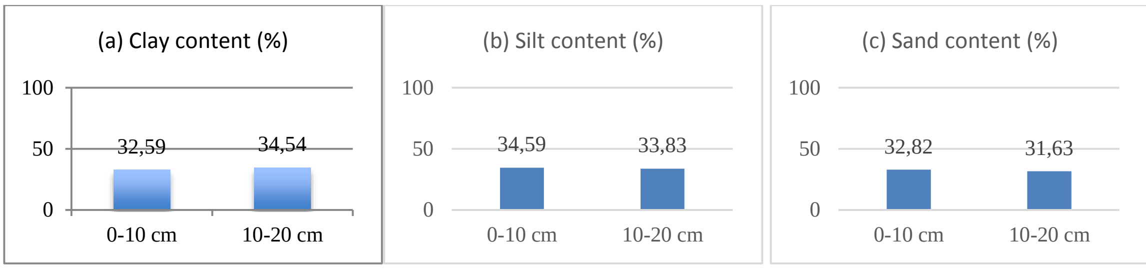

Figure 2. Clay (a), silt (b) and sand (c) contents (%) at the surface and subsurface soil of the study area.

Organic Matter, pH, and Moisture Content

Analyses showed that OM and moisture content were higher at the subsurface (Figure 3a, c) but the differences were not significant. As for pH, it was higher at the surface and the difference was significant ($p<0,05$) (Figure 3b). Low OM at surface can be explained by poor vegetation cover, leading insufficient plant residues to be decomposed. Also, since the study area is on a young alluvial material, ideal soil horizons have not been formed yet and there was almost no O and/or A horizons observed at the field. Depending on OM distribution, it was expected for subsurface soil to be higher in respect to moisture content and pH values since OM can hold more water and release organic acids increasing soil acidity.

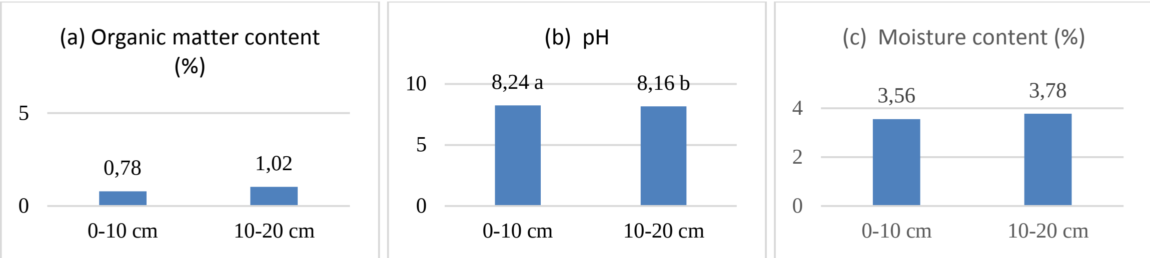

Figure 3. Organic matter (a), pH (b) and moisture (c) contents (%) at the surface and subsurface soil of the study area.

Lime Content and Electrical Conductivity

Both lime content and electrical conductivity was found to be higher at subsurface layer at the study site (Figure 4a, b). When looking at low pH values measured at the surface, it was unexpected to have low lime content at the surface. As for electrical conductivity, the results indicate that there is not a salinity problem in the whole study area.

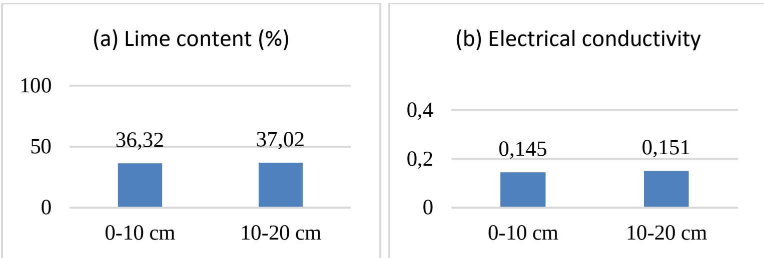

Figure 4. Lime content (a) and electrical conductivity (b) at the surface and subsurface soil of the study area.

Aggregate Stability and Dispersion Ratio

As expected, the aggregate stability of the soils in the study area was higher at the subsurface than the surface and this difference was statistically significant (p<0,01) (Figure 5a). This outcome can be easily associated with the semi-arid feature of the area as there is severe erosion at the surface where we have found low aggregate stability values. In addition, the OM content and moisture content being higher at the subsurface may be one of the responsible factors for the aggregate stability to be also higher there. A closely related feature, dispersion ratio, also resulted in significant differences (p<0,01) between the two layers as it was higher at the surface (Figure 5b), meaning that the top part of the soil in this region is much more fragile for water and wind erosion, a typical process for such semi-arid lands.

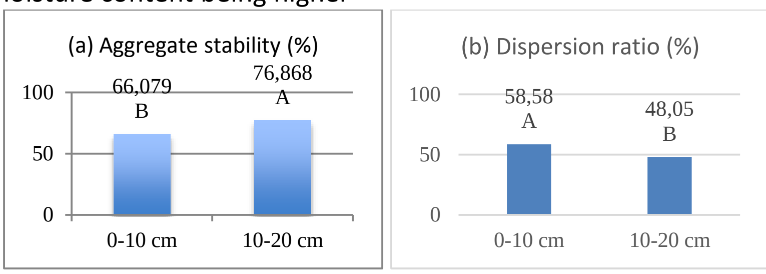

Figure 5. Aggregate stability (a) and dispersion ratio (b) at the surface and subsurface soil of the study area.

Bulk Density, Hydraulic and Air Conductivity

Bulk density of the soils in the study area was higher at the top but the difference was not significant (Figure 6a). This was an expected result since the erosion has been removing any OM accumulation, a possible factor to decrease bulk density at the surface. Insufficient vegetation cover can also be one of the factors, limiting root penetration into the soil to create more spacious area for water and air, causing higher bulk density at top for this study. As for both hydraulic and air conductivities, they were resulted in higher values at the subsurface layer with no significant differences (Figure 6b, c). As explained above, especially with the OM and moisture contents being high at the subsurface, it can be said that these results were expected.

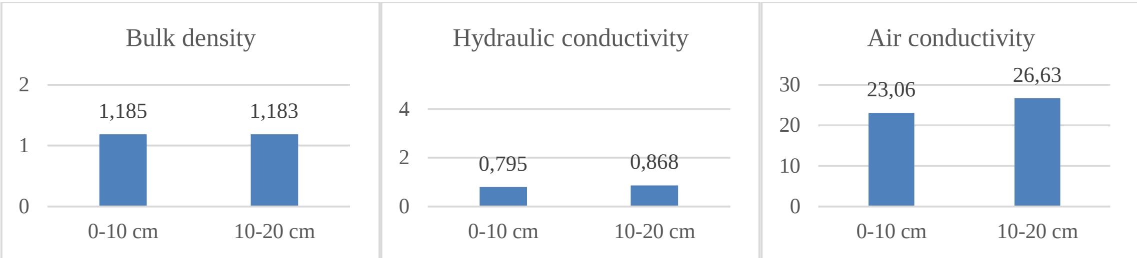

Figure 6. Bulk density (a), hydraulic conductivity (b) and air conductivity (c) contents (%) at the surface and subsurface soil of the study area.

Conclusion:

The research was carried out in the Pamukcular Watershed, a severely eroded semi-arid region in Yusufeli, Artvin. Several soil physical and chemical characteristics were analyzed to determine the effect of water and wind erosion in the area. The overall results of very low OM, moisture content, and hydraulic conductivity as well as very high aggregate stability, bulk density, and dispersion ratio values were the clear indicators of severe erosion problem in the study area. In addition, the results and field observations showed that soil horizons have not yet been formed ideally due to the alluvial and colluvium materials found in the study area. It was clear that the climate, especially the lack of rain and drought, and very terrain landscape, along with water and wind erosion play the major role on shaping this region. In order to protect soil resources in the site, there is a need for more research in respect to the soil, climate and vegetation characteristics.

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