The Variation of Soil Biological Properties along a Hill-Slope

Farshid Nourbakhsh and Maryam Khalili Rad

Abstract—The distribution pattern of soil biological properties in eroded toposequences is not well understood. Seventy five composite soil samples were collected equally from 0-15 cm depth of the five distinct slope positions including summit, shoulder, backslope, footslope and toeslope. The greatest values of organic C, total N, inorganic N (IN), potentially mineralizable N (PMN), microbial biomass N (MBN), soil basal respiration (SBR), and L-glutaminase activity (LGA) were consistently observed in the toeslope. In conclusion, biological and biochemical properties of soils on the semi-arid toposequence were not uniformly distributed. It can also be concluded that lower slope positions generally provide greater microbial biomass and activity.

Keywords—Toposequence; Potentially Mineralizable N; Microbial Biomass Nitrogen; Soil Basal Respiration; L-Glutaminase Activity.

I. INTRODUCTION

SEMI-ARID and arid ecosystems comprise more than 25% of the earth’s land area and it is continually increasing due to desertification. Compared to other terrestrial ecosystems, the soils in these ecosystems possess less organic matter and plant residue, indicating that soil characteristics and processes can be largely influenced even by a small change management practices [1]. Topography is a main factor that exerts a considerable control on soil properties and hence, affecting soil processes. Even small topographic change can result in large difference in edaphic conditions across relatively short distances [2].

Soil biological pools and processes are key elements that control ecosystem functions [3]. It was also found that soil enzyme activities have not been uniformly distributed along a slope, so that the lowest activities was observed in the higher slope positions and the greatest activities were observed in the lower positions [4]. We hypothesized that slope position of an eroded semi-arid toposequence can influence the distribution of C and energy sources of soil microorganisms and consequently, soil microbial activities and biochemical properties are thought to be influenced. The objective of this study was to identify the effect of slope position on some soil biochemical and microbiological properties in a semi-arid eroded toposequence.

II. MATERIALS AND METHODS

The soils were sampled along a toposequence in Godar Kabk region (51° 10’ E, 31° 53’ N) west central Iran. The five identified slope positions are summit, shoulder, backslope, footslope, and toeslope (Table I). The mean annual precipitation of the study area is 576.1 mm and the mean annual temperature is 10 °C. Rain-fed wheat (Triticum aestivum L.) had been cultivated in the area. Fifteen composite soil samples were collected from 0-15 cm depth of each slope position, while each composite sample contained three soil cores. Soil samples passed through a 2-mm sieve and kept at 4 °C before biological and biochemical analysis. A sub-sample was air-dried for determination of OC, TN, and IN.

Soil organic C (OC) was determined by wet oxidation, total N (TN) by Kjeldahl digestion and distillation, inorganic N (IN) was determined by steam distillation procedure. Potentially mineralizable N (PMN) was measured anaerobically. Soil basal respiration (SBR) was determined by titration of CO2 trapped in NaOH solution after treating with BaCl2 solution. Fumigation-extraction procedure was used to determine soil microbial biomass N (MBN). L-glutaminase (LGA) was assayed by a toluene and buffer based technique [5]. The experiment was designed as completely randomized block with 15 replications. The analysis of variance and regression analysis were performed following normality and variance homogeneity tests by SYSTAT.

III. RESULTS AND DISCUSSIONS

Soils belonging to different soil orders were found on the different slope positions (Table I). The observed variation in soil type implies that soil forming processes have not uniformly performed along the slope. Summit, shoulder, and backslope positions were eroded (Table I).
A general increasing trend was observed in soil OC and TN along the slope from summit to toeslope. The greatest (13.4 g kg⁻¹) and lowest (5.9 g kg⁻¹) OC contents were observed in toeslope and summit, respectively (Table II). The two upper slope positions of the study area are eroded (Table I) therefore, the increasing pattern of OC content along the slope can be attributed to the pattern of sediment transport. The backslope, footslope and toeslope can be considered as sediment sinks and hence, are expected to regularly receive organic C-rich topsoil materials removed from eroded higher slope positions. It is suggested that the greatest content of soil OC was observed in the backslope because, the slope position was strongly covered by forest and was consequently provided with greatest amount of litter compared to other slope positions [6]. In the present study, the whole area possessed similar vegetation and lithology and therefore, the slope position was the most important factor controlling soil properties. Distribution of TN along the slope (Table II) followed the pattern of soil OC. The similar increasing trend in TN contents from higher to lower slope positions indicates that soil OC and TN are controlled by identical factors.

Inorganic N was significantly higher in toeslopes, while it was close to those of OC and TN (Table II). Significant correlation was observed between TN and PMN (r = 0.53, P<0.001, n = 75). It is suggested that the greatest content of soil OC was attributed to the pattern of sediment transport. The backslope, footslope and toeslope can be considered as sediment sinks. The distribution pattern of LGA along the slope was similar to that of SBR (Table II). A significant correlation was also observed between LGA and SBR (r = 0.70, P<0.001, n = 75). It was demonstrated that LGA and dehydrogenase activity are strongly associated along a slope with various management practices [4]. It can be concluded that LGA is a sensitive bioindicator to slope position. It can be hypothesized that greater content of OC in lower slope positions have provided greater sources of C and energy for microbial biomass and consequently has resulted in greater LGA.

The MBN values increased towards the lowest slope positions. The greatest value of MBN was observed in toeslope. Summit and shoulder had no significant difference and showed the least MBN values (Table II). The results of this study showed that microbial biomass was also sensitive to slope position (Table II).

The SBR was significantly increased along the toposequence from higher to lower slope positions (Table II). Our results demonstrated that the distribution pattern of SBR and MBN are similar. This is consistent with the correlation of MBN and SBR (r = 0.52, P<0.001, n = 75) and also with the results obtained earlier [1]. The difference in the distribution pattern of SBR across the slopes can probably be related to the different distribution of substrate (OC) availability.

The distribution pattern of LGA along the slope was similar to that of SBR (Table II). A significant correlation was also observed between LGA and SBR (r = 0.70, P<0.001, n = 75). It was demonstrated that LGA and dehydrogenase activity are strongly associated along a slope with various management practices [4]. It can be concluded that LGA is a sensitive bioindicator to slope position. It can be hypothesized that greater content of OC in lower slope positions have provided greater sources of C and energy for microbial biomass and consequently has resulted in greater LGA.

Overall, our results clearly showed that biological and biochemical properties of the soils on the semi-arid eroded toposequence strongly depended on the slope position. It can also be concluded that lower slope positions in the eroded toposequence generally provide greater C and energy sources for soil microbial populations and hence, lead to greater microbial biomass and activity.

**TABLE II**

**EFFECT OF SLOPE POSITION ON SOIL BIOCHEMICAL AND MICROBIOLOGICAL PROPERTIES**

<table>
<thead>
<tr>
<th>Slope positions</th>
<th>Length of slope positions (m)</th>
<th>Slope gradient (degree)</th>
<th>Erosion (Mg ha⁻¹ year⁻¹)</th>
<th>Soil texture</th>
<th>Soil taxonomy</th>
</tr>
</thead>
<tbody>
<tr>
<td>Summit</td>
<td>43</td>
<td>&lt;5</td>
<td>42.87</td>
<td>Clay Loam</td>
<td>Typic Haploxerepts</td>
</tr>
<tr>
<td>Shoulder</td>
<td>90</td>
<td>15</td>
<td>60.76</td>
<td>Silty Clay</td>
<td>Typic Calcixerepts</td>
</tr>
<tr>
<td>Backslope</td>
<td>137</td>
<td>30</td>
<td>14.78</td>
<td>Sandy Clay Loam</td>
<td>Calcic Haploxeralfs</td>
</tr>
<tr>
<td>Footslope</td>
<td>131</td>
<td>10</td>
<td>0</td>
<td>Silty Clay</td>
<td>Typic Haploxerepts</td>
</tr>
<tr>
<td>Toeslope</td>
<td>125</td>
<td>&lt;5</td>
<td>0</td>
<td>Silty Clay</td>
<td>Chromic Haploxerepts</td>
</tr>
</tbody>
</table>

Different letters within columns represent significant difference (P < 0.05, LSD).
SOC: soil organic C; TN: total N; IN: inorganic N, Nana: anaerobic index of available N; MBN: microbial biomass N; SBR: soil basal respiration; LGL: L-glutaminase activity.

REFERENCES


